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THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

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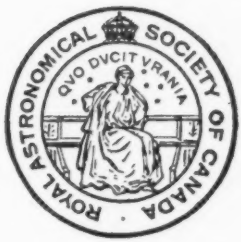

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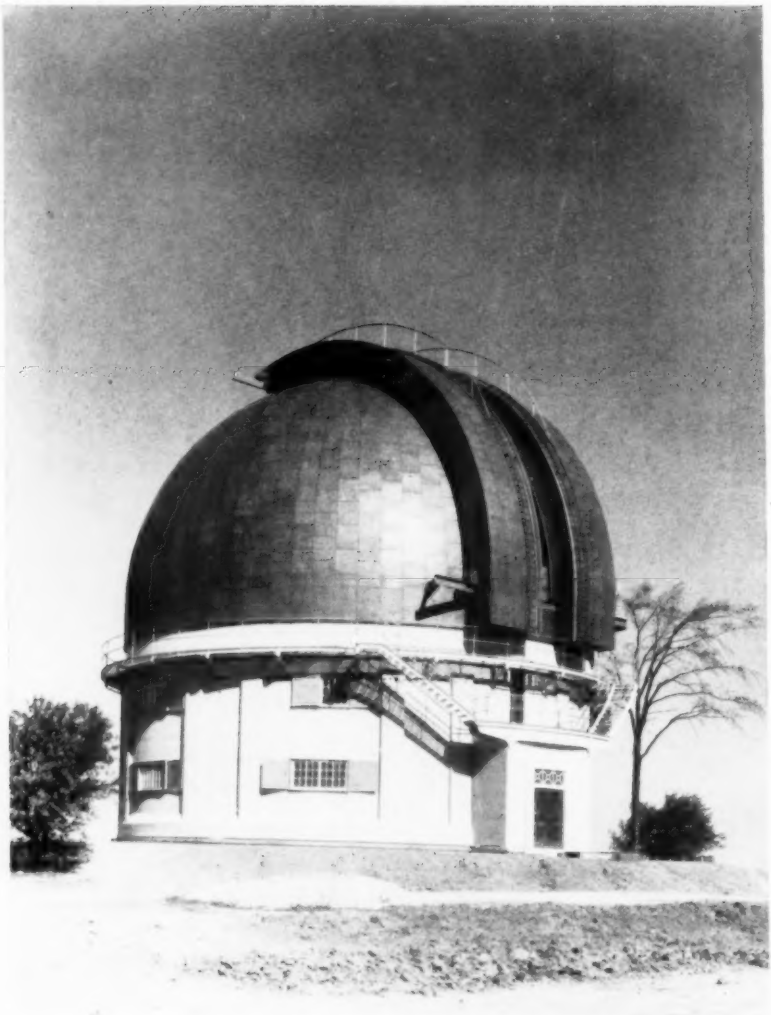
PLATE II.

VIEW OF THE DAVID DUNLAP OBSERVATORY FROM THE AIR.

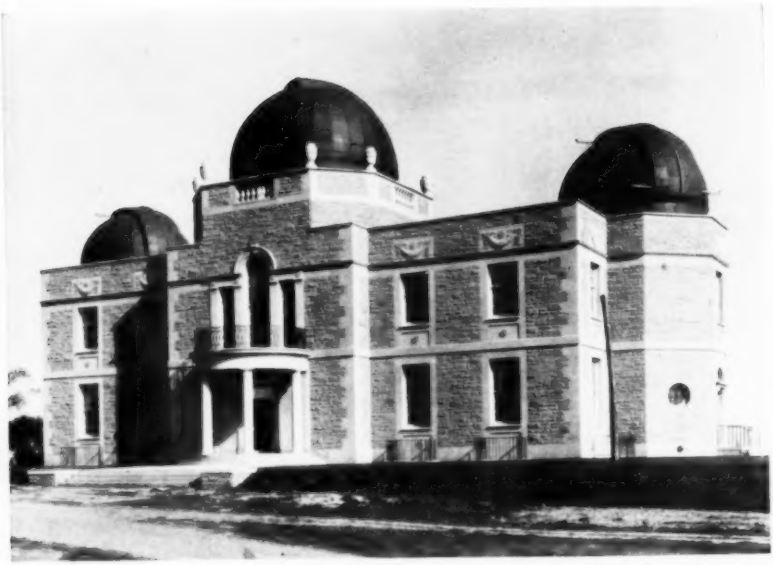
PLATE III.



THE GREAT DOME

Journal of the Royal Astronomical Society of Canada, 1935.

PLATE IV.



THE ADMINISTRATION BUILDING, DAVID DUNLAP OBSERVATORY.

PLATE V.

MRS. DUNLAP OPENING THE DOOR OF THE OBSERVATORY.

THE JOURNAL
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OF CANADA

Vol. XXIX, No. 7 SEPTEMBER, 1935 Whole No. 246

THE OPENING OF THE DAVID DUNLAP OBSERVATORY

By F. S. H. AND H. S. H.

With Plates II—IX

I.

THE CEREMONY IN THE AFTERNOON

ON the afternoon of Friday, May 31, 1935, occurred an event of major importance in the annals of Canadian astronomy. On that date the David Dunlap Observatory was formally opened, and presented to the University of Toronto by the generous donor, Mrs. Jessie Donalda Dunlap.

Three years earlier, on September 10, 1932, the corner-stone was laid by her son, David Moffat Dunlap. During the intervening years this pleasant hilltop, just south of the village of Richmond Hill, Ontario, has been a scene of constant activity. First, the magnificent office building was constructed, then the giant dome for the seventy-four inch telescope, and then within it the massive mounting of the telescope was erected. In Corning, N.Y., on June 21, 1933, was cast the huge disc of "pyrex" glass; in Newcastle-on-Tyne, England, the latter was shaped to the correct figure by the firm which built the mechanical parts of the telescope. On May 2, 1935, the finished mirror was received at the observatory, and on May 7, the day after the King's Jubilee celebration, it was placed in its cell and next day was attached to the tube of the telescope.

But long before the activity started on the site of the observatory there had been much activity in the mind of the planner of the

observatory, Professor Clarence Augustus Chant. For years he had cherished the dream that the University of Toronto might be the possessor of a large observatory which should become one of the leading research centres of the astronomical world. Early in the last decade the late David Dunlap had expressed his interest in the project and after his untimely death Mrs. Dunlap indicated her willingness to establish such an observatory as a memorial to her husband—and the largest telescope in the British Empire came into being.

The date of May 31, 1935, was especially selected for the formal opening, as on that day Professor Chant reached the age of seventy. Invitations were extended to various astronomers, members of the University, the Royal Astronomical Society of Canada, and government officials. However, admission was not restricted to formal invitations only, and interested members of the general public were also permitted to attend. About 1300 people were present.

Distinguished guests journeyed from a large part of Canada and the United States. Those coming from the greatest distances included Sir Frank Dyson, from Greenwich, England; Mr. Cyril Young and Mr. F. G. H. Bedford, from Newcastle-on-Tyne, England; Dr. V. M. Slipher, from Flagstaff, Arizona; and Dr. W. E. Harper, from Victoria, B.C.

Chairs were placed on the west side of the Administration Building. The broad entrance steps to the building served as the speakers' platform, and were flanked on either side by chairs for many of the distinguished guests and those connected especially with the observatory. Lowering clouds of the morning had disappeared, leaving a brilliant May sun to give a warmth and cheerfulness to the open-air gathering.

The exercises began at 3 o'clock with the entrance of His Honour, the Lieutenant-Governor of Ontario, and lasted an hour and a half. At their conclusion the huge shutters of the dome were opened, and the building thrown open for inspection. The Administration Building was decorated with apple blossoms, and the offices of Prof. Chant and Prof. Young were gay with large bouquets of spring flowers, a gift of Mrs. Dunlap. Refreshments were served in a marquee on the east side side of the building, through the kindness

of Mrs. Dunlap. Members of the observatory staff were stationed throughout the observatory to answer questions and demonstrate the equipment.

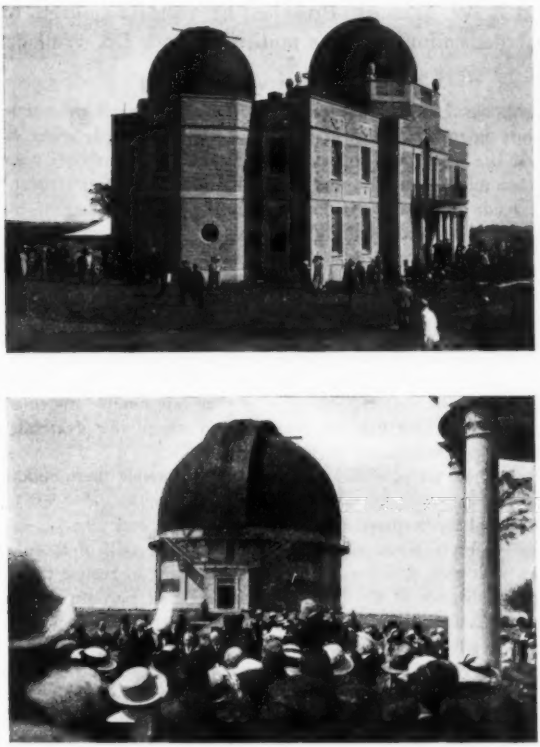


FIG. 1—Two views of the opening of the Observatory.
Below—President Cody reading messages of congratulation.
Above—After the formal ceremony.

The opening ceremonies were broadcast in the afternoon, and also recorded and rebroadcast over leading Canadian and United States stations in the evening.

The ceremonies commenced with the singing of the National Anthem on the arrival of His Honour, the Lieutenant-Governor of Ontario, Dr. Herbert Bruce. The President of the University, the Honourable and Reverend H. J. Cody, presided, and called upon the Reverend E. W. Wallace, President of Victoria College, to read the prayer of dedication. As the audience stood, Dr. Wallace spoke as follows:

O Lord, our Lord, how excellent is thy name in all the earth, who hast set thy glory upon the heavens. When we consider thy heavens, the work of thy fingers, the moon and the stars which thou hast ordained; what is man that thou are mindful of him, and the son of man that thou visitest him? Yet thou hast made him but little lower than thyself, thou makest him to have dominion over the works of thy hands.

Thou hast set us in a vast dwelling place and hast given us minds and hearts curious and patient, daring and skilful to search out the secrets of thy universe and to make it our home. And thou thyself art with us in that search. Thy Spirit is the inspiration of all scientists and poets, all dreamers of dreams and explorers of thy heavens.

For all those who in the past have thus studied to extend man's knowledge of thee and of thy handiwork, we offer to thee our humble and hearty thanks.

More especially this day we pray thee to accept our grateful thanks for this undertaking now brought to its completion.

For her, whose purpose and noble gift made possible these buildings and all that they contain;

For him, whose memory is here enshrined for ever;

For the vision of those who planned and for the skill of those, in this and other lands, who with patience and devotion wrought to realize that vision;

For the assistance of thy Spirit in bringing that purpose and thought and all that manifold activity to their perfect consummation;

We praise and glorify thy name, O God.

And now, we would dedicate to thee and to the service of mankind these buildings and these instruments, that they may ever be used for the extension of man's knowledge of thy truth. Grant, we beseech thee, that those who labour here may be guided by thy Spirit out into new and untrodden paths, in all humility and reverence, as children seeking to understand the mind and the heart and the works of their father, knowing that as they search for new light, that light itself is already coming to meet their search.

O thou, who art the light of the minds that know thee, the life of the souls that love thee, and the strength of the hearts that serve thee; grant that in this place and throughout our university true knowledge may grow from more to more, that the light of truth may be shed abroad in our city and our province, in our land and in all lands. Help us and all men by thy Spirit so

to know thee that we may truly love thee, so to love thee that we may fully serve thee, whom to serve is perfect freedom. And this we ask through Jesus Christ, our Lord.

Amen.

The key to the Observatory was handed to Mrs. Dunlap by Mr. A. S. Mathers of the firm of Mathers and Haldenby, the architects who designed the building. This key was beautifully wrought of gold. On one side was embossed the crest of the University and on the reverse side was engraved Mrs. Dunlap's name and the date of presentation. With this key Mrs. Dunlap opened the main door of the Administration Building. She then presented the Observatory to the University, represented by Dr. D. Bruce Macdonald, Chairman of the Board of Governors, with the words,

"In loving memory of my husband, David Alexander Dunlap, I now present this astronomical observatory to the University of Toronto, believing that this memorial will express his deep interest in astronomy, and I hope through its equipment great advances will be made in the science."

Dr. Macdonald, in accepting the gift of the Observatory, reminded those present that the telescope, pointing toward the sky, was indicative of a great deal of the man in whose memory it was being donated. David Dunlap was always looking upward, searching for the higher things of life. He was a man of gentle manner, courteous to others, open-minded and open-hearted, ever ready to help a worthy cause. Though he was not great in the eye of the general public, yet he accomplished many things in his lifetime. Above all things he was full of the milk of human kindness, and that is something which is greatly needed in the world to-day. The Observatory would stand as a memorial to future generations, substantial, well worth while.

President Cody stated that a large number of greetings had been sent to Dr. Chant and to the University by various scientific organizations and leading representatives of various sciences. Of these, he read a number to the assembly, some of which were as follows:

From Sir Arthur Eddington, *Cambridge, England* (Cable)

Wishing great success to the new telescope.

(*Signed*) Eddington.

From Sir James Jeans, *London, England.*

Thank you so much for your letter and invitation. I am so sorry I shall not be able to be present at the opening of the telescope.

Unfortunately the end of May is precisely the time at which I find it impossible to leave my various appointments in this country.

I need hardly tell you that I wish you all good luck and success with the new telescope.

(*Signed*) James Jeans.

From Professor Frank Schlesinger, *Yale University, New Haven, Conn., President of the International Astronomical Union* (Telegram).

On behalf of the International Astronomical Union I congratulate you and the University on the opening of the David Dunlap Observatory. We wish for the observatory, and confidently expect, a long career of usefulness in furthering the progress of our science.

(*Signed*) Frank Schlesinger, *President.*

From R. A. Gray, B.A., *General Secretary of the Royal Astronomical Society of Canada.*

The Council of the Royal Astronomical Society of Canada extend to the President and Board of Governors their congratulations and good wishes at the completion of the buildings and of the telescope presented by Mrs. D. A. Dunlap in memory of her husband.

It is our desire to place on record our satisfaction and recognition of the munificent donation of Mrs. Dunlap to the realm of Astronomy, with the earnest hope and confident expectation that it will be a means of extensive scientific development through the Department of Astronomy in the University of Toronto.

(*Signed*) R. A. Gray, *General Secretary.*

[*Further congratulatory messages received by Professor Chant appear at the end of this account of the official opening.*]

Addresses by Distinguished Persons.

President Cody then called on several of the distinguished men present to address the gathering.

His Honour, the Lieutenant-Governor of Ontario

I am confident that the expression of thanks of Dr. Bruce Macdonald is most warmly and enthusiastically seconded by everyone present. Mrs. Dunlap

has indeed rendered a tremendous service to the University of Toronto by donating so munificent a gift. I am sure, too, that I shall be but voicing the sentiments of the citizens of this Province when I say that this Observatory will always be regarded not only as a gift to the University of Toronto but as one to Ontario—and, indeed, to Canada. May I therefore seize this welcome opportunity to assure Mrs. Dunlap that the citizens of Ontario are deeply grateful to her for having equipped the astronomers and scientists of Canada with so magnificent an instrument. I most heartily congratulate them upon their good fortune. To bring the heavens nearer by magnifying the stars is in all probability second only to bringing heaven nearer, and it must be most gratifying for them to know that from now on their attempts to wrest from the skies those celestial secrets computable only in terms of multi-millions and infinite infinities, will be made easier as vision becomes easier—thanks to Mrs. Dunlap and this Observatory.

Perhaps the wonder of man's mind is never so graphically or so dramatically revealed as when an astronomer sets out to chart limitless space, dropping the plummet of his intelligence down fathomless canyons of darkness or finding his way along ultimately immeasurable avenues of light. In the act of expressing to Mrs. Dunlap the pleasure and pride and grateful appreciation of the citizens of Ontario and in congratulating also the University of Toronto upon receiving so splendid a gift I would like also to pay tribute—all too inadequate tribute I fear—to the intellectual power, the patience and the zeal by which the gentlemen who study the heavens have already succeeded in laying bare to our awestruck gaze so many of the wonders and so much of the illimitable grandeur of this our own and other universes.

One day an astronomer who was speaking of his work quoted such figures and spoke of such dimensions when describing other stars and constellations of stars that by comparison our little earth appeared to be nothing more than a midge spinning out its brief day in the light of a million, million suns. The astronomer was thereupon approached by a man, who in philosophic tone and with an airy wave of his hand, remarked "It would seem that astronomically speaking man is somewhat less than nothing." "My friend," replied the astronomer, "astronomically speaking man is the astronomer."

No words of mine could convey so charming, so adequate and at the same time so well-deserved a compliment to astronomers and their work. We have with us a most distinguished assembly of them. I gladly make way for them to speak to us, as only astronomers can speak of the very instruments by which they are enabled to launch their minds quite literally into infinity.

I know Mrs. Dunlap's magnanimity in placing at their disposal this great observatory must have awakened in them sensations very like those the young poet John Keats experienced when he wrote:

> "Then felt I like some watcher of the skies
> When a new planet swims into his ken."

May this Observatory enable them to detect the intrusion of any and every new planet in order that they may reap an ever richer harvest of knowledge from the heavens of their contemplation.

The chairman then called upon Professor Chant to give some account of the history of the observatory.

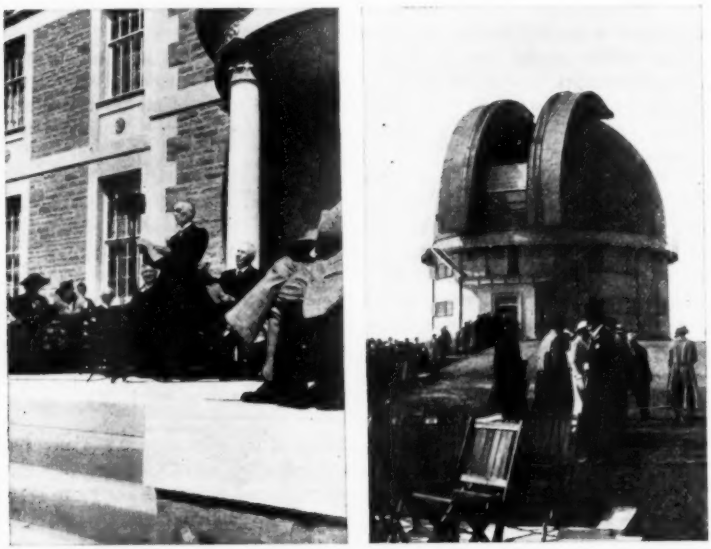


FIG. 2—Two views at the opening ceremony.

Left—Professor Chant addressing the gathering.

Right—The visitors proceeding to the dome to see the great telescope.

PROFESSOR C. A. CHANT, *Director of the David Dunlap Observatory*

I propose to make a brief historical statement regarding the David Dunlap Observatory, and hope I shall be pardoned if I begin by repeating a story which I related at the laying of the corner-stone on September 10, 1932.

In accordance with astronomical calculation, a comet known as Pons-Winnecke's appeared in the sky in the spring of 1921. This comet was discovered by Pons in 1819 but was not seen again until 1858 when Winnecke rediscovered it. Its successive returns were then carefully observed, since it was found that, owing to the attraction of the planet Jupiter, its period and

distance from the sun were continually changing. As a consequence it was predicted that the comet might actually collide with the earth on July 1, 1921. Special interest was thus aroused in this celestial visitor. In order to illustrate how the earth and the comet were coming together I constructed a model which I showed at a lecture delivered in the Physics Building of the University during the latter part of May. At the end of the lecture I took ten minutes to make a plea for an astronomical observatory for the University and the city, and I threw on the screen some slides to indicate the nature of the project. I may say that these were prepared some years before in connection with a scheme in which it was intended that the city, the Royal Astronomical Society of Canada and the University would unite. After the lecture a gentleman came up to me and said he was interested in my project. He said his name was David Dunlap. In the months which followed I had some correspondence with Mr. Dunlap regarding astronomical matters and he used to come to the meetings of the Astronomical Society. I cherished the hope that he might provide the observatory, but he passed away in the autumn of 1924. Two years after this, in December, 1926, I wrote to Mrs. Dunlap and recounted how I had met her husband and referred to the pleasant relations I had with him. I stated that I had hoped that Mr. Dunlap would provide the observatory, but, now that he had gone, I ventured to ask if she could consider the project as a memorial to her husband. The response was cordial and I was invited to visit her after the busy Christmas season. In January 1927 I called, and then found that Mrs. Dunlap shared fully her husband's tastes and was on friendly terms with the stars.

As no public action on the project could be taken for three years, we spent our time quietly, though profitably, in locating a suitable site and in gathering information regarding equipment. My colleague, Dr. Young, and I would study a large-scale contour map of the country within fifty miles of Toronto and would then explore the places we had selected. When we had found a possible site Mrs. Dunlap would inspect it. Well do I remember driving up yonder lane on a sunny afternoon in June 1928, parking the car near the old barn, clambering through a barbed-wire fence and walking to the top of the hill on which we now are. "This is the site," she said. As a matter of fact we examined many other sites but found none which we considered as satisfactory.

In May 1930 the order was given for the great telescope; we knew it would require three years for its construction. Then on September 10, 1932, the corner-stone of the Administration Building was laid by David Moffat Dunlap, the son of the donor. The building was completed in a year. The excavation for the mighty cement pier for the great telescope was begun in March 1933 and this work was completed in three months. The order for the steel dome was given in November 1931 and it arrived at the water-front in Toronto on July 31, 1933. It was erected within six weeks. The telescope

mounting arrived in Toronto on October 15, 1933, and within two weeks was mounted on its pier.

There was some delay with the immense disc of glass for the main mirror of the telescope, but on June 21, 1933, a happy and interested party from Toronto saw the 2½-ton disc poured from a superior type of "pyrex" glass at the Corning Glass Works, Corning, N.Y. After remaining in the annealing kiln for three months it was examined, declared good and then shipped to England to be ground and polished. Within its 5-ton shipping case, on the second day of this very month, it was moved into the great dome through an opening made in the wall, and five days later the mirror was safely placed in its cell and then attached to the telescope. The telescope is now completed.

Before resuming my seat I wish to make some acknowledgments.

Upon the name of Mrs. Jessie Donalda Dunlap we need not dwell. Were it not for her outstanding benefaction there would be no observatory here. To her all the credit is due.

Then I must mention the name of a person who, I know, would strongly demur if I told him I intended to do so. I refer to Mr. John B. Holden, the former business associate and friend of Mr. Dunlap and the legal adviser and friend of Mrs. Dunlap. Mr. Holden is a faithful guardian of her interests, but he appreciated at once the fine quality of the memorial and has heartily co-operated in making the observatory worthy of its object.

Of the work of the architects, Messrs. Mathers and Haldenby, I need only say that their creation is acclaimed by everyone as beautiful, appropriate and effective. The contractors also, Messrs. Sullivan and Fried, the Ramsay Contracting Co., Jordan-Roberts of Brantford, the Dominion Bridge Co., as well as the numerous staff of the Superintendent of Buildings of the University, all deserve commendation. One must specially mention the English firm, Sir Howard Grubb, Parsons and Co., which supplied the great telescope and the steel dome. It is a miracle of mechanism, and our relations with the firm have been very cordial. It is much to be regretted that Sir Charles Parsons, the distinguished head of the firm, did not live to see the telescope completed. He had a lively interest in it. I have been intimately associated with the great project in all its details, and everyone employed on it seemed to me to realize that it was a very special undertaking which demanded his best efforts.

I wish also to refer to the assistance rendered by the Royal Astronomical Society of Canada, the Council of which has loaned us the valuable technical portion of its library. We hope the Society will find it even more accessible here.

I may remark that the first three volumes entered in the accession book of our library bear the autograph of D. A. Dunlap.

Finally let me refer to the ability and enthusiasm of my colleague, Professor R. K. Young. No mathematical problem which we encountered was too hard for him to solve, no mechanical intricacies were too difficult for him to

master and no labour was too long for him to undertake and carry to a conclusion.

Friends have remarked to me that I have spent a long time in my endeavour to secure this observatory. True it is that thirty years is a considerable time, but it is as nothing compared to the decades and centuries during which a stream of astronomical research will proceed from this noble memorial, bringing honour to the name it bears and to its donor, and also conferring distinction on our land.

The chairman then asked for a few words from the one who was directly responsible for the construction of the great telescope.

MR. CYRIL YOUNG, *General Manager of Sir Howard Grubb, Parsons & Co., Newcastle-on-Tyne, England.*

When I paid my first visit to the Observatory last Tuesday I could not help feeling proud that the firm of Sir Howard Grubb, Parsons & Co., with whom I am associated and whom I have been very kindly invited to represent today, should have had the honour of building the 74-inch Reflector, the principal instrument in this observatory, so kindly provided by Mrs. Dunlap's munificence.

In designing and constructing the Telescope and Dome, we have had to collaborate with Dr. Chant and Dr. Young, and I am glad to say that our relations throughout have been most happy. We have been very fortunate in having on the spot Mr. F. Jno. Bell, who so ably looks after Messrs. Parsons' interests in Canada. I wish to take this opportunity of acknowledging the assistance given by my chief, Mr. Bedford, who is here today. He has given us every facility to obtain the help of any of the experts at the Heaton Works who could in any way contribute to the successful manufacture of the Telescope. This assistance has been most generously given and I am sure they would feel proud if they could see today the results of their contribution.

I must specially mention the name of Mr. Armstrong who was responsible for working the 74-inch mirror. When I explain that every portion of the surface of an astronomical mirror should be worked true to its theoretical contour to within 2-one-millionths of an inch you will understand that the task of making a successful mirror is a very arduous one.

Some weeks ago Dr. Young paid a special visit to Newcastle-on-Tyne in order to test Mr. Armstrong's work, and from the results of these tests we have every reason to believe the mirror to be a very good one.

I cannot conclude without a reference to the enterprise of The Corning Glass Works, which manufactured the "pyrex" disc for the mirror. This was the largest disc they had made up to that time, although since then they have produced several larger, including one of 200 inches diameter. The greatest credit is due to Dr. O. A. Gage and his colleagues at Corning.

My only regret is that Sir Charles Parsons did not live to be here today.

The next speaker was introduced by the chairman as a distinguished representative of British astronomy.

SIR FRANK DYSON, *K.B.E., Astronomer Royal* 1910-1933

In the first place I should like to congratulate the University of Toronto on the beautiful observatory and magnificent telescope given to them by the generosity of Mrs. Dunlap. Then I think Mrs. Dunlap should be congratulated on the worthy memorial she has made to her husband Mr. David Dunlap. As the Latin poet says, "it is a memorial more lasting than brass," and Mr. Dunlap, who was keenly interested in astronomy, would have desired no better tribute. Lastly, Professor Chant is to be congratulated on the consummation of his hopes on this day, his 70th birthday. Prof. Chant has been a great power in furthering the study of astronomy in Canada. Besides the number of students he has taught he took a large share in establishing the Toronto Astronomical Society which in after years became the Royal Astronomical Society of Canada and has spread right across the Dominion.

I have had the opportunity of seeing the telescope. Its general appearance is most workmanlike. I was very glad the contract was given to the firm of Sir Howard Grubb, Parsons and Co. Sir Charles Parsons was the famous engineer who by the invention of the steam turbine comes next to James Watt in getting power out of steam. Sir Charles was the son of Lord Rosse, who made the biggest reflecting telescope of the nineteenth century, and was interested in the manufacture of optical glass. Later he associated himself with the famous firm of Sir Howard Grubb, which had made many large telescopes, and thus acquired the experience of Mr. Cyril Young, who became the manager of the telescope works at Newcastle, and of Mr. Armstrong who was a real artist in the figuring of mirrors and lenses. I am quite sure the 74-inch mirror is a very perfect instrument. Both the mirror and the spectroscope, which was constructed by the firm of Adam Hilger, have passed the severe scrutiny of Prof. R. K. Young. Then I cannot imagine a more beautiful site for an observatory than Richmond Hill. It is far enough from Toronto to escape smoke and glare and sufficiently near for the teaching purposes of the University.

But a telescope is not much good without suitable astronomers to work it. I should like to congratulate Prof. Chant on his staff. I have only recently met Dr. Young but know of his work at Lick and Victoria. But I had the pleasure of meeting Prof. Hogg at Victoria. Prof. Plaskett with whom I was staying took me to the 72-inch. Naturally Prof. Hogg was there. I was not surprised to see Mrs. Hogg, because I knew she was a Harvard graduate and was working on Cepheid variables in the cluster Messier 2. But I was surprised to see a baby a few weeks old sleeping in the dome. That shows the enthusiasm of her parent. With enthusiasm and skill great things will be accomplished, and I look forward with every confidence to the future of the David Dunlap Observatory.

President Cody then requested Professor Curtis, of the comparatively near University of Michigan, to address the gathering.

DR. HEBER D. CURTIS, *Director of the Observatories of the University of Michigan*

It is a great pleasure and honour that is mine today in bringing to the University of Toronto the congratulations and good wishes of the University of Michigan, a sister institution of learning lying on the other side of that imaginary line that divides two peoples who are so essentially the same in every respect.

In all our great universities there are groups of men who attempt to find out things about this universe and to translate and pass this knowledge on to the rest of the world. The geologist teaches us the lore of things beneath the crust so that we may mine our coal and iron; the botanist learns to know the life and needs of plants and makes this knowledge help us with our crops; the engineer builds our bridges and teaches us how to make steel, steam and electricity our slaves; the historian or economist shows us the errors of the past and how we may avoid them in the present. But I should not personally care to be the historian; we are apt to believe implicitly the lessons that the geologist, the botanist, or the engineer teaches us, but we humans seem to go right on making the same old mistakes in so far as the lessons of history are concerned.

The astronomer, by and large, renders no such utilitarian service to mankind and, on the whole, I am rather glad that this is so. He gives us rather something that enlarges our souls in a knowledge of the universe without; the inflexible and beautiful laws of the greater spaces; he brings to us aggregates that are so inconceivable in mass, or distance, or in the time factor that we can not go far wrong in applying to this external universe the tremendous adjective, —infinite. And it is a wonderful thing that our souls may thus come in contact with the infinite, for we do not live by bread alone.

It is unnecessary to repeat here the details of telescopic equipment and power that make the David Dunlap Observatory so notable an adjunct to the scientific work of the University. We of the world of science prophesy for the new observatory a long and useful life. In this fine plant there will be carried on in all the decades to come researches of value on the world of the stars without—their elements, constitution, and motions. Many of the studies thus made will doubtless seem too highly technical and abstruse for the man in the street, yet all will have their individual parts in that greater picture of the universe that the astronomer is trying to paint for the world.

It is thus an unusual pleasure for me to join with this audience in congratulations to the University of Toronto at the dedication of this fine plant and new tool of research; our felicitations as well to Dr. Chant on this his natal day that marks also the successful fruition of his decades-long dreams

and strivings; and our sincerest thanks to Mrs. Dunlap whose generosity has made possible for the University an acquisition so notable as the David Dunlap Observatory.

The next speaker was the representative of the great Harvard University at Cambridge, Mass.

PROFESSOR HARLOW SHAPLEY, *Director of the Harvard Observatory*

Dr. Shapley congratulated Canada on the opening of such a magnificent observatory. As judged by the quantity and quality of equipment, Canada was now the outstanding country in the astronomical world. The only other place of comparable size in which there was similar interest was South Africa, and there the interest was not native, but rather due to outsiders who had set up observatories in that country owing to its situation in the southern hemisphere and to its very fine astronomical climate. He particularly stressed that in an observatory such as this, the balance should be maintained between popular interest in astronomy and freedom of the staff to pursue the researches that such generous equipment warranted. He welcomed the observatory as a further important element in the making of western hemisphere astronomical research a thing for the future generations to think about. Dr. Shapley complimented Mrs. Dunlap on the magnificence and suitability of her contribution to science. He also congratulated Dr. Chant on his birthday, and especially on the "pretty trifle" he had received as a birthday present. He feared Dr. Chant's tastes might become so extravagant that in the future, suitable birthday gifts might be really difficult to supply.

Dr. Shapley also spoke of his personal interest in Toronto as an astronomical centre in that three of the astronomers here, Frank S. Hogg, Helen Sawyer Hogg, and Peter M. Millman, had been "doctored" by him at Harvard University. He thus felt he had a greater interest and responsibility here than at any other observatory but his own, and suggested that this mutual interest be a basis of constructive co-operation.

The last speaker of the afternoon was introduced as a graduate of the University of Toronto, who had achieved distinction in the astronomical world by his work at the observatories at Ottawa and Victoria.

W. E. HARPER, M.A., *Acting Director of the Dominion Astrophysical Observatory, Victoria, B.C.*

It is certainly a great privilege and honour to be invited to participate in the formal ceremonies connected with the dedication of this great observatory. There is, moreover, a peculiar pleasure that comes to myself, and I am sure to all who know Dr. Chant well, in the thought that the dream of his life has at last been fulfilled. The establishment of this observatory with its marvellous

telescope for studying the secrets of the heavens is a fitting climax to his professorial career in the University.

As Editor also of the *Journal* of the R.A.S.C. since its inception over thirty years ago he has devoted himself unselfishly to building up astronomical centres across Canada where leadership is given to the study of this, the oldest of the sciences. It is not at all surprising, then, that in addition to the formal greeting which has just been read from the General Executive of the Society there should come from these various centres across Canada congratulations and good wishes to Dr. Chant and to the University which receives this splendid gift.

I understand that Dr. Chant, who seems to remain ever young, will now be free to devote his whole time to astronomical research. He will have associated with him several who have been co-workers with myself at Victoria. It might, therefore, be thought that we would cherish some animosity towards him and the University for enticing away some of our best workers in the persons of Dr. Young, Dr. Millman, Dr. Hogg and his talented wife. Such is not the case, for while we regret losing them we recognize that they have greater opportunities here. Moreover, in the early days, before we could secure our own, Dr. Chant was kind enough to loan us much needed equipment and he has ever been a good friend of the Victoria observatory. Surely, then, we can in some measure attempt to repay his kindness by allowing him and the University to have some of our best workers.

This telescope, as has just been mentioned, has a diameter two inches greater than ours at Victoria and now ranks as the second largest in operation. By reason of thus taking precedence in size over our own, it might be suspected that we would be envious. Again, such is not the case. Like a loyal British Columbian, I shall only say that with the wonderful climate we enjoy and the consequent high quality of our seeing, we feel we can afford to accept a handicap of a mere couple of inches. That is a mere trifle, you know.

There is a well-worn saying that one may judge of the degree of the civilization of any nation by the provision which that nation makes for the study of astronomy. Now that you good people of the east have a really worthwhile observatory we westerners will believe there is hope for the east yet! Seriously though, speaking for the Dominion Astrophysical Observatory, we welcome this new observatory into the field of astronomical endeavour.

We expect great contributions from this observatory and I am sure we shall not be disappointed. It is a great thing to be able to make possible such achievements and greater still to be the one willing to do so.

Mrs. Dunlap may well be assured that for generations to come people will point with pride to this establishment as a worthy example of how to perpetuate the memory of a loved one. We may well use scriptural language and say that it will be as a city that is set upon a hill which cannot be hid or as a lamp which giveth light to all the world.

May her example serve to stimulate others to apply their wealth to similar memorials seeking to discover Truth, for "The truth shall make you free."

II.

Special Convocation of the University

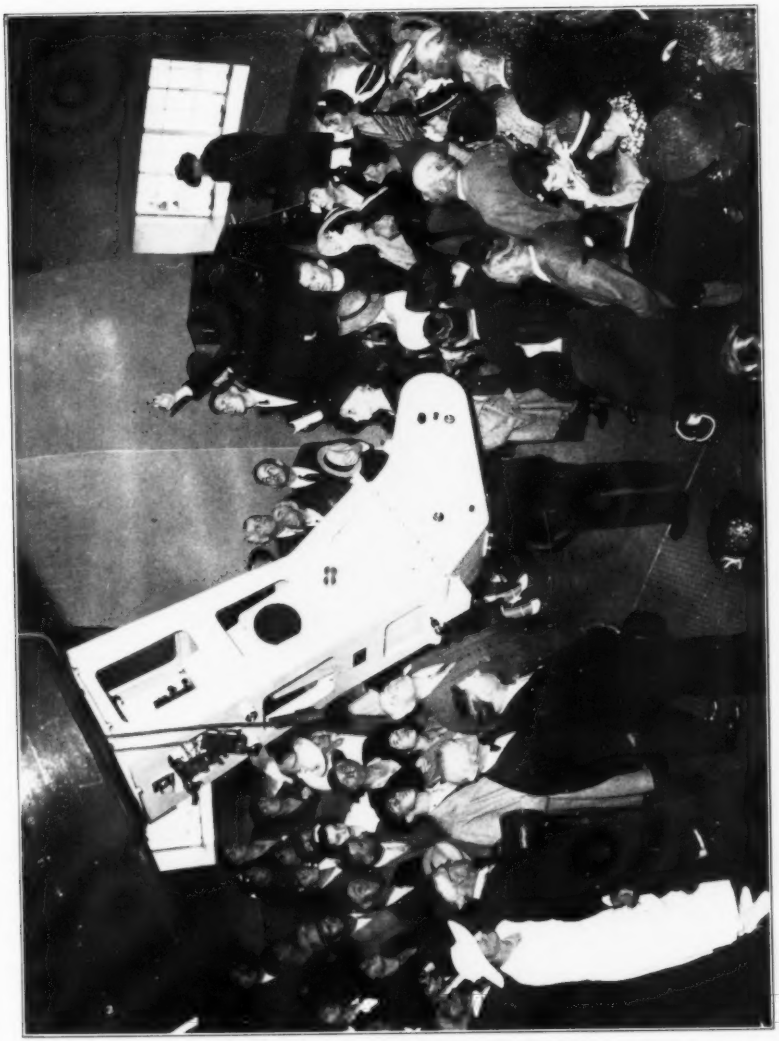
THE second impressive ceremony of the day took place in the evening when the University of Toronto called a special convocation to confer honorary degrees on six persons who had made notable contributions to astronomy. The degree of Doctor of Laws was conferred on Mrs. Dunlap, Sir Frank Dyson, and Prof. Chant; and the degree of Doctor of Science on Dr. Harlow Shapley, Dr. V. M. Slipher, and Mr. W. E. Harper. The Chancellor of the University, Sir William Mulock, was unable to be present because of illness, and President Cody occupied his chair. Present on the platform, besides university officials, the recipients of degrees, and those who read the citations, there were His Honour the Lieutenant-Governor, Dr. Bruce; the Hon. L. J. Simpson, M.D., Minister of Education, and his Deputy Minister, Dr. Duncan MacArthur; the Hon. J. A. Faulkner, M.D., Minister of Health; His Worship the Mayor of Toronto, Mr. James Simpson; Sir Joseph Flavelle, and Mr. W. L. Mackenzie King.

The candidates for degrees who would ordinarily have been presented to the Chancellor by President Cody were presented by various prominent members of the faculty who read the president's citations. After each candidate had been given the degree, he inscribed his name in the Golden Book of the University, which contains the names of all the recipients of honorary degrees. The ceremonies were enhanced by the fact that the leader of the opposition in the House of Commons of Canada, Mr. Mackenzie King, was present and spoke brilliantly though briefly.

During the course of the evening, President Cody spoke with regret of the retirement of Professor Chant as head of the Department of Astronomy and Director of the Observatory, but stated that he would remain on the staff in an honorary capacity. Dr. Cody announced the appointment of Dr. Reynold K. Young as the new Director of the Observatory.

PLATE VI.

AFTER THE FORMAL OPENING.
Sir Frank Dyson Mrs. Dunlap Mr. John B. Holden



WITHIN THE GREAT DOME.

The spectrograph attached to the mirror cell of the 74-inch telescope is seen.

PLATE VIII.

C. A. Chant F. W. Dyson R. K. Young

BEFORE THE ADMINISTRATION BUILDING

PLATE IX.

THE CANDIDATES FOR HONORARY DEGREES.

At rear—H. Shapley, W. E. Harper, V. M. Slipher.
At front F. W. Dyson, C. A. Chant, Mrs. Dunlap, President Cody in the Chancellor's Gown.

Preliminary to the conferring of degrees the President remarked that this was a red-letter day in the history of the University of Toronto. "It marks," said he, "a decisive advance in our scientific equipment. Today has been formally opened the David Dunlap Observatory, a magnificent gift to the University made by Mrs. Dunlap in memory of her honoured husband, that his name may be perpetuated in connection with the high realm of astronomical research, and that this University may share with other observatories throughout the world the task of investigating the field of stellar velocities and spectral photometry and in similar co-operative labours."

He then called on Professor E. F. Burton, head of the Department of Physics in the University, to present Sir Frank Dyson for the degree of LL.D. Professor Burton read the following citation:

Mr. Chancellor, I present to you one who has just retired from the historic post of Astronomer Royal and director of the Royal Observatory at Greenwich, an institution founded in 1675 by that Stuart monarch with a scientific bent, King Charles II.

Frank Watson Dyson was born in an English Baptist parsonage, and has never forgotten his fundamental religious associations, as is witnessed by his acceptance in 1921 of one of the vice-presidencies of the British and Foreign Bible Society. Educated at Bradford Grammar School and Trinity College, Cambridge, he graduated with the mathematical blue ribbons of Second Wrangler and Smith's Prizeman. In 1894 he became chief assistant at the Royal Observatory, Greenwich, and in 1899 secretary of the Royal Astronomical Society. In 1905 he resigned these duties to become Astronomer Royal for Scotland. This post he held till 1910, when he was appointed Astronomer Royal at Greenwich. For twenty-three years he held this high office, retiring in 1933 at the remorseless demand of the age limit.

Many honours have come to him in recognition of his astronomical researches. He was knighted in 1915 and made a K.B.E. in 1926. He was elected a member of the Royal Society in 1901. Edinburgh, Oxford and Cambridge have given him their highest academic distinctions.

From 1891 onward he has published innumerable scientific papers. Three outstanding features of his scientific achievements may be mentioned: (1) at Greenwich Sir Frank's chief work lay in the astronomy of position—the determination of the proper motions of the stars. To determine these motions, there is need of a clearly defined programme, great persistence, and observations of the utmost precision. This kind of work may lack the spectacular

features which appeal to the many, but it constitutes the very foundation on which astronomical progress rests.

(2) Sir Frank accompanied the eclipse expeditions of 1900, 1901, and 1905, as Greenwich chief assistant, and his services in connection with these show that he would have won equal eminence in astrophysics if he had devoted himself to that branch of astronomy.

(3) When Einstein in 1915 published his paper on general relativity, it was at once recognized that the new theory had an important bearing on astronomy. Einstein himself had suggested that the tests of its correctness were astronomical in nature and that one of them could be applied by observations made at a total eclipse. Two English expeditions were planned—even when the Great War was raging—to observe a total eclipse in May, 1919. One went from Cambridge to Africa under Sir Arthur Eddington; the other from Greenwich to Brazil under Sir Frank Dyson. Both were successful, and obtained evidence in support of Einstein's theory. These brilliant observations brought great fame to English astronomy, and in making them Sir Frank Dyson took a leading part.

We honour our University in adding to our company this great man of singular modesty and singular achievement.

I, therefore, present to you, Mr. Chancellor, Sir Frank Watson Dyson, K.B.E., F.R.S., LL.D., D.Sc., former Astronomer Royal, to receive at your hands the degree of Doctor of Laws, *honoris causa.*

Hon. N. W. Rowell, K.C., presented Mrs. Dunlap for the degree of LL.D. in the following words:

This University has been glad to invest with its highest academic honours certain notable women whose services to others have richly deserved public recognition. To-night we add another to this selected group—the gracious lady whose wifely affection and wise benefaction have made possible the erection of this great observatory, Mrs. Jessie Donalda Dunlap.

From those to whom much is given, much by divine law is required. Mrs. Dunlap has sought faithfully and with discrimination to discharge her duties of stewardship in the use of her possessions. It is not for me this evening to mention the manifold causes she has generously helped. I speak only of some of the educational institutions which have been able to advance because of the munificent aid which her husband and she herself have given to them: St. Andrew's College, the Toronto General Hospital, the Medical and Psychological departments of this University.

The climax of her helpfulness to the University of Toronto has come in the provision of the observatory and its site as a memorial to her late husband, David Alexander Dunlap. She shared her husband's interest in astronomy, that science which at once humbles and exalts the mind and soul of man, and responded with considered, yet prompt, generosity to the suggestion that

she should do this great thing for the furtherance of astronomical research in Canada. Today she has handed to the University a superb addition to its scientific equipment, in the confident hope that through these new facilities the confines of astronomical knowledge may be ever enlarged, the mysteries of the universe may become more intelligible, and the starry heavens above may, as Immanuel Kant said, in conjunction with the moral law within, continue to bear witness to Him "who is before all things and in whom all things consist".

The University of Toronto wishes to mark its appreciation of Mrs. Dunlap's public philanthropies to this community and its profound gratefulness for her many benefactions to this institution by conferring upon her the highest academic distinction within its power.

I, therefore, present to you Mrs. Jessie Donalda Dunlap that she may receive at your hands the degree of Doctor of Laws, *honoris causa*.

Professor Lachlan Gilchrist, President of the Royal Astronomical Society of Canada, then presented Professor C. A. Chant for the degree of LL.D., in the following statement prepared by President Cody:

It is not the happy lot of many to see their dreams come true and attain the goal of their life's effort. To Professor Chant this rare experience has come. Today, his seventieth birthday, is the crowning day of his long career. It is our privilege to rejoice with him in his rejoicing.

He graduated from this University in 1890. It was my good fortune to be a fellow-student, graduating one year earlier. We were both officers in that famous and still persisting organization—the University College Literary and Scientific (now Athletic) Society. Another member of our committee was George Howard Ferguson. A year after his graduation, Dr. Chant was appointed Fellow and next year Lecturer in Physics. When the new department of astrophysics was established in 1907 he was made associate professor, and became full professor in 1918. This post he has held till the end of this academic year, when he retires under the age limit. I am glad to say that the Board of Governors has appointed him Professor Emeritus of astrophysics and Emeritus Director of the Observatory, as well as its Honorary Librarian and director of publications.

His whole life has been devoted to the teaching of astronomy and to emphasizing its value as a cultural subject in a liberal education and as a fine discipline for the advanced student. From the beginning of his work he has urged that the University should have an observatory, and so make some fresh contribution to our knowledge of astronomy. In this programme for astronomical advance in Canada, great interest was taken by Mr. David A. Dunlap, an enthusiastic amateur in the field of astronomy and a member of the Royal Astronomical Society of Canada, one who believed that (in Kepler's

phrase) astronomers were thinking God's thoughts after Him. Some time after his death in 1924, when Professor Chant suggested to Mrs. Dunlap that she provide an observatory as a fitting memorial of her husband, she gave a sympathetic and munificent response—and the issue has been the great observatory and telescope dedicated to day to the cause of astronomical research.

There are other phases of Professor Chant's work that deserve to be mentioned. (*a*) He was one of the earliest experimenters in wireless. While he was an undergraduate, Hertz in Germany discovered the method of producing electric waves and thus opened the way for the future development of wireless telegraphy and radio. In 1895 when Mr. Chant was a lecturer in physics, he constructed the necessary apparatus and first demonstrated to a Toronto audience the properties of these waves. In 1899 before the Canadian Institute he showed, perhaps for the first time in Canada, how to send and record a wireless message.

(*b*) He has played an important part in the development of the Royal Astronomical Society of Canada. He joined the original society in 1892, and from 1904-7 was its president. In 1905 he edited its transactions. In 1907 he began the publication of the *Journal* of the Society, which is now in its 29th volume and is sent to all parts of the world. At his suggestion local centres of the Society have been organized in various parts of Canada.

(*c*) He has written admirable and widely-used text books. In collaboration with Dr. F. W. Merchant he prepared the *High School Physics*. The first edition appeared in 1911 and a revised edition in 1923. All the Canadian provinces have used it as a text book and it has had a wide circulation in the United States. More than 275,000 copies have been issued. The same authors have published three other school text books which have had a combined circulation of 140,000.

In 1928 he wrote a small book on astronomy called "Our Wonderful Universe." This has been published in England, Canada and the United States, and has been translated into German, Czech and Polish.

In 1933, in collaboration with Professor E. F. Burton, head of our department of physics, he published a text book of college physics, and this is being used in many colleges in Canada and in the United States.

(*d*) He has made five expeditions to observe total eclipses of the sun. In the 1922 expedition to Western Australia evidence was secured in verification of Einstein's theory.

Surely at the close of his long academic career in this University and on the day of the opening of the Dunlap Observatory—his realized dream—we do well to honour our own Professor Chant, a scientist "indeed in whom is no guile."

I present to you, Sir, Clarence Augustus Chant, M.A., Ph.D., Fellow of the Royal Society of Canada, Professor of Astrophysics in this University, that he may receive at your hands the degree of Doctor of Laws, *honoris causa*.

Professor Harlow Shapley was presented for the degree of D.Sc. by Professor J. L. Synge in the following words:

Equipment for astronomical research has nowhere been brought to a higher degree of efficiency than in the neighbouring Republic. Some of the finest observatories of the world are there situated. Mt. Wilson Observatory has at the moment the largest telescope in existence, and the glass is still cooling for the marvellous 200-inch mirror which the Mt. Wilson organization will some day add to its instruments for observing the heavens.

One of the most famous astronomers in the United States I now present to you in the person of Dr. Harlow Shapley. From the University of Missouri from which he graduated, he went to Princeton as a Fellow. From 1914 to 1921 he was a member of the staff of the Mt. Wilson Observatory. From this he came to Harvard in 1921 to be Director of the Observatory and Paine Professor of Astronomy, and has proved himself a worthy successor to the late Edward C. Pickering. His researches have been in the fields of photometry, spectroscopy, and cosmogony.

While he was at Princeton he made notable contributions to the theory of variable stars, especially those known as eclipsing variables. This work he greatly extended at Mt. Wilson, and was able to utilize it in determining hitherto unmeasured distant portions of the universe. This led on to investigations into the nature and distance of star clusters, and their relation to our system of stars. He gained new views of the structure and dimensions of our milky way or galactic system, and revealed that our universe was infinitely greater than we had previously believed it to be. What a being is man, able to understand and formulate theories about this vast yet intelligible universe!

Professor Shapley is a member of many scientific societies, including the National Academy of the United States, the American Astronomical Society, the Royal Astronomical Society of Canada, and the Royal Astronomical Society of London.

He was Lowell Lecturer at Boston in 1922, Exchange Lecturer in the Belgian Universities in 1926, Halley Lecturer at Oxford in 1928, and George Darwin Lecturer in 1934. He has been awarded the Draper Medal of the National Academy in 1926; the Universities Medal, Brussels, 1926; the medal of the Society of Arts and Sciences 1931; and the gold medal of the Royal Astronomical Society of England in 1934.

Among his early publications were papers on astronomy in Horace and in Lucretius. From Lucretius may be quoted (in translation) lines which fairly describe our distinguished visitor: "Therefore the living force of his soul gained the day; on he passed far beyond the flowing walls of the world, and traversed throughout in mind and spirit, the immeasurable universe; whence he returns a conqueror, to tell us what can, what cannot, come into being."

We are grateful for his presence with us to-day.

I present to you, Mr. Chancellor, Harlow Shapley, one of the world's great astronomers, to receive from you the degree of Doctor of Science, *honoris causa*.

Professor Reynold K. Young then presented Director V. M. Slipher, of the Lowell Observatory, Flagstaff, Arizona, for the degree of D.Sc.:

For centuries the fiery planet Mars has been an object of interest to astronomers and laymen alike, and as telescopes became larger in size and better in quality strange details were detected on the surface of the planet. In 1877, the Italian astronomer, Schiaparelli, reported that he had seen faint straight markings on the planet, and after some years of observation he drew a map of the surface of Mars on which was a network of lines. These were so straight and regular that he called them *canali* (channels), but the world called them canals. Percival Lowell, member of a well-known Boston family and a distinguished graduate of Harvard, was greatly attracted by these observations and determined to devote himself and his means to investigations on Mars and the other planets. After a search for the best site he established the Lowell Observatory at Flagstaff, Arizona, at an altitude of 7250 feet above the sea, and gathered about him a number of able and enthusiastic young men.

One of these was Vesto Melvin Slipher, a native of the Hoosier State, Indiana, and a graduate of its State University. He joined the staff of the Lowell Observatory in the year of his graduation, 1901; he became assistant director in 1915, and director in 1926.

Mr. Slipher's special field of research is spectroscopy, and his investigations on the planets, not merely on Mars, have been of outstanding value. With skill, ingenuity and abounding patience, he has secured much information regarding the atmosphere, the surface conditions and the rotation of the planets. One of the latest results deduced from his spectrum photographs is that there is much of the poisonous gases, ammonia and methane (or marsh gas) in the atmosphere of the outer planets of our solar system.

But he has not confined his attention to our family of planets. Indeed he has attacked some of the most difficult problems of the great universe of stars beyond. From his early spectra of the stars he found evidence of the presence, throughout space, of clouds of calcium vapour, a discovery now recognized as of great importance.

His spectrum photographs were among the first to lead to the belief that the diffuse nebulae owe their illumination to the bright stars in their neighbourhood. By the inclination of the lines in the spectra of some spiral nebulae he was able to demonstrate that such nebulae are moving outward on the arms of the spiral.

In recent years we have been told that our universe is expanding, that every part is moving away from every other part. This result is deduced from

Einstein's theory of relativity. One reason for the general acceptance of this view is, that, before the general theory of relativity was announced, Mr. Slipher had actually obtained photographs which showed that some of the spiral nebulae were moving in space with speeds of several hundred miles a second.

In most of his researches his work has been that of pioneer, and has proven to be of fundamental importance in formulating our theories of cosmogony.

He has been honoured by election to many scientific societies, by receiving honorary degrees, and by the award of the Lalande Prize and Gold Medal from the Paris Academy in 1919, and the Gold Medal of the Royal Astronomical Society in the year before Dr. Shapley received it, 1933. He has also been the George Darwin Lecturer in 1933.

I, therefore, present to you, Mr. Chancellor, Vesto Melvin Slipher, Ph.D., LL.D., Sc.D., director of the Lowell Observatory and a great interpreter of the starry universe, that he may receive at your hands the degree of Doctor of Science, *honoris causa.*

Professor Samuel Beatty, head of the Department of Mathematics in the University, presented Mr. W. E. Harper, of Victoria, B.C., for the degree of D.Sc., in the following words:

Canadians have taken their part in recent years in the work of astronomical research. In a new country like ours, it has not been unnatural that emphasis in the field of science should be placed on subjects that seemed to be of immediate utility. Yet pure science has made great strides on its own account, and among pure sciences astronomy has gained increased prestige and aroused fresh interest by reason of recent spectacular discoveries which have vastly enriched our knowledge of the universe. The life work of Professor Chant has not been in vain, and astronomy has come into its own. Two of our graduates, Dr. J. S. Plaskett, formerly director of the Dominion Astrophysical Observatory at Victoria, B.C., and his son, Professor Harry Plaskett, now Savilian Professor of Astronomy in the University of Oxford, have made great contributions to this fascinating and overawing science.

To-night I present to you another of our graduates whose astronomical work has been of signal value. He is in a sense Dr. Chant's "son in the astrophysical faith." Professor and pupil stand side by side in this Hall to-night to receive the highest honour their Alma Mater can bestow upon them.

William Edmund Harper came from that Ontario County of Bruce. From the Owen Sound Collegiate Institute he came to this University in 1902 and took the course in Mathematics and Physics. At Professor Chant's request, the Senate of the University in 1905 instituted a new division in this department, known as Astronomy and Physics. It was established in time for the graduating class of 1906, and Mr. Harper was the first graduate in this section. In order to encourage the study of astronomy, the Royal Astronomical

Society of Canada had offered a gold medal to the candidate obtaining highest standing in the new course. The first award was made to Mr. Harper. The day of his graduation he received notice that he had been appointed to the staff of the recently founded Dominion Observatory at Ottawa. There he remained until 1919 when he was transferred to the new observatory at Victoria, B.C.

For the last twenty-nine years Mr. Harper has laboured effectively in the field of astronomical research, especially in astrophysics. With great skill and patience he has taken and measured thousands of photographs of the spectra of the stars, and from them the velocities of the stars and other wonderful results have been determined. He has discovered a large number of binary stars, which are pairs of suns far out in the depths of space revolving about each other. He has, it is said, computed more orbits of such systems than has any other human.

In co-operation with Dr. R. K. Young, of our own department of astrophysics, Mr. Harper determined, from their spectra, the absolute brightness, and hence the distance, of over 1100 stars, a great and important achievement. Only on such observations can an intelligent view of the universe be based.

Mr. Harper is a Fellow of the Royal Society of Canada and a past president of the Royal Astronomical Society of Canada. He has done much to popularize astronomy by his articles in newspapers and magazines, and by lectures and radio addresses. He is now the Acting-Director of the Astrophysical Observatory at Victoria—over which Dr. J. S. Plaskett presided for many years.

The work of this alumnus of our University has brought distinction to himself, to his native land and to his Alma Mater, who now greets and honours her academic son.

I present to you, William Edmund Harper, that he may receive from you the degree of Doctor of Science, *honoris causa.*

Addresses by the Recipients of Degrees

The chairman then invited the recipients of degrees to address Convocation, and the first to respond was Sir Frank Dyson, who spoke as follows:

I am commissioned by Mrs. Dunlap to say how highly she appreciates the great honour you have conferred upon her by giving her the degree of Doctor of Laws. She wishes me to express her thanks for the many kind things which have been said of her and to her. For myself, I am very proud to be a Doctor of Laws of your famous University. I know that two of your graduates have been Prime Ministers of the Dominion of Canada. But I have a peculiar gratitude to the University of Toronto. The Medical Faculty, Banting, McLeod, Collop and Best, by the discovery of insulin, prolonged my sister's life for many years. As regards astronomy, nearly all the Canadian

astronomers, Chant, Meldrum Stewart, Young, Hogg, Millman and the Plasketts—father and son—were graduates of the University of Toronto, and many of them Prof. Chant's pupils. Now you have this magnificent observatory and the best I can wish for you is that it may become as famous as the Greenwich Observatory, which has been of service to astronomy for 260 years. As one who has been many years at Greenwich I am glad to come as a representative of the English astronomers but am very sorry my distinguished colleagues, Eddington and Jeans, found it impossible to leave England. The honour you have conferred on me is all the greater because it is associated with Mrs. Dunlap and the distinguished representatives of astronomy from Canada and the United States.

The chairman then called on Dr. C. A. Chant, who said:

My first wish is to thank the Senate for conferring on me the high degree of Doctor of Laws, here, in the presence of so many of my friends and in such distinguished company.

As has been intimated by the President, I have come to the close of a long period as an instructor in the University, and perhaps I may be allowed to offer a few reminiscences.

This thirty-first of May has been a wonderful day in my life. I suppose it might well be marked by a red letter or a golden number, as of old, and yet nothing of that sort is needed to remind me of it or for my complete satisfaction.

In 1891, a year after graduation, I returned to the University as Fellow in the Department of Physics, at $500 for the session. One year later I received a permanent appointment as lecturer at $800. During the operation of moving to our new and lovely home up at the Observatory I came across the letter from the Assistant Provincial Secretary informing me of that appointment; also a similar letter one year later stating that the salary had been increased to $900. At the present time that salary looks small, and I suppose it was, but I had no complaints whatever to make. I was glad of the opportunity to get back to my Alma Mater.

Thus began my association with the young men and women from the high schools of Ontario who year after year came up to the University. Surely they are the finest in the whole world! To assist in moulding their minds and characters has been my great privilege. A teacher can have no greater joy than to see his students win high place in the world; and there have been so many classes which have gone forth in the last forty-four years that everywhere I am greeted by my former students.

Then also I entered on a life-time of the study of science and, as Charles Kingsley has remarked, "Science, like virtue, is its own reward." While that is true of all sciences, I think it is especially so of astronomy.

I think my mind was first turned in that direction when I was at the

high school, by reading a school book entitled "Geography Generalized," by Robert Sullivan, of Dublin, Ireland. I have the book still. It has my eldest brother's name in it, with the date 1870, although this is a copy of the 27th edition which was issued in 1861. It contains a well-arranged and very readable introduction to astronomy. I note in the book some statements indicative of the epoch. The author continues to give the name Herschel to the planet next beyond Saturn which even then was known on the continent as Uranus. He also gives the distance of the earth from the sun as 95 million miles, instead of 93, and the velocity of light at 192,000 miles per second instead of 186,000.

Soon after being appointed to the University staff I joined the Astronomical and Physical Society of Toronto, which in 1903 became the Royal Astronomical Society of Canada. There I met a number of practical observing astronomers, who further stimulated my interest in astronomy. I was president of the Society for four years and formed some valued friendships with the members. I venture to hope that I have been of service to the Society.

In this way I was led to realize the slight attention paid to astronomy in the University and the lack of means for practical instruction, and I looked about for some way to improve matters. I suggested to my colleagues in Mathematics and Physics that I be given the instruction in Astronomy and they readily agreed. This was nearly thirty years ago, and it is interesting to look back on the growth of the department of astronomy. As the years went by my hopes for equipment for the University broadened, but I had not dared to expect anything so fine as that which, thanks to the great generosity of Mrs. Dunlap, we now possess. The completion of the David Dunlap Observatory has exceeded my rosiest dream. In the coming years, yes, in not many years, I predict with the greatest confidence, its staff will place it in a foremost position in the world of astronomy.

I conclude with one more word. Nothing has pleased me quite so much as the very generous words of appreciation of my colleagues in the University, those among whom I have lived ten, twenty, in some cases, over forty years.

The next speaker to address the gathering was Dr. Harlow Shapley.

Dr. Shapley, in thanking the University for this honour and paying further tribute to Mrs. Dunlap, stressed that the completion of the observatory was only the starting of its life and work. If it were to fulfil the purpose of its foundation, it must with care and diligence select and pursue active and fruitful research programmes. He spoke briefly of some of the difficulties and limitations encountered in attempts to solve the various problems of the universe, and jokingly condemned the universe for being so uncoöperative with research workers. He referred particularly to such difficulties as the blocking

up of regions of the Milky Way with absorbing matter and suggested that Omnipotence should clean up the milky way of cosmic debris.

Yet, given the universe in its present uncoöperative form, it was all the more urgent that we devise means of learning its structure in spite of difficulties. He suggested four chief fields in which he thought the equipment of the observatory and experience of its staff might produce profitable results. These comprised the determination of spectroscopic binary orbits, both for statistical analysis of characteristics of the stars, and for detailed studies of some of the more accessible members of this group; the quantitative analysis, from the astrophysical point of view, of stellar spectra; the study of star clusters and the study of the cosmic debris, as found in meteors, asteroids, and general absorbing matter in space.

The chairman then asked Dr. V. M. Slipher to speak, which he did in the following words:

I wish to express my sincere thanks to you and to the University of Toronto for honouring me with this degree. This is indeed the greater honour because it is given by an internationally great University.

I deeply appreciate such approval of my scientific work. If I have in some measure deserved this recognition it is largely because of the favourable conditions under which I have been able to study the heavens at Flagstaff. The Lowell Observatory where it has been my good fortune to do my astronomical work is well equipped instrumentally and is favourably situated atmospherically. It is located in the dry climate of the southwestern United States, is 7250 feet above sea level and has on the nearby mountains an auxiliary station at 11,500 feet altitude.

Thus surrounded, and possessed of some predilections to adventure, it has not been difficult for me to undertake new and apparently very unpromising problems, even if they required extreme effort in observing. Hence, in consequence of these opportunities, of good health, and good friends, I am here this evening and I appreciate and thank you for this honour.

May I take advantage of this opportuity to speak a few words concerning another matter which is of very great moment. Reference of course is had to the formal opening this afternoon of the excellent new David Dunlap Observatory. This magnificent observatory, given to the University by Mrs. Dunlap, is sure to be of important service to astronomy and to add still further to the high repute of your University.

On such an occasion some persons not familiar with the developments of astronomy might ask why is another great telescope needed—is not the field covered already? But with astronomy, as with medicine and many other sciences, the more we learn the more questions arise to be answered, and often times these new ones are at least as important as were the original ones. But perhaps we ought to be more specific in answering this question. And in

doing so I cannot do better than to draw examples from my experience at the Lowell Observatory. Founded in 1894 by Dr. Percival Lowell for the study of Mars and the other planets, such study has been carried on there continuously since, employing every new means that could be applied to its researches. And whereas much advance has been made in our knowledge of Mars regarding his atmosphere, temperature, seasons, etc., there is still much to learn about this the best known of the planets.

The same story is to be told of the other planets. Thirty odd years ago when taking up the study of the spectra of the planets it was possible with commercial plates to photograph only from the violet to the orange. But now, thanks to repeated improvements in sensitizing dyes, it is possible to include three times the old range of wave-lengths. By thus being able to reach far out through the red into the heat spectrum, we have added enormously to our knowledge of planetary atmospheric absorptions. And recently we have been able to determine that the remarkable absorptive action of the atmospheres of the giant planets (which has long been a most puzzling question) is due to their containing surprisingly large amounts of methane gas. This substance, commonly called marsh-gas, is produced in our air by decaying vegetation, but that on the giant planets must have arisen not from *organic matter* but from *inorganic processes* of these planets. Here again important advance in knowledge raises many questions and it encourages us to push forward with the aid of this knowledge to further understanding of these neighbour worlds.

Then, breaking new ground, in 1906, prompted by the publication of Chamberlin and Moulton's planetesimal theory of the origin of our solar system, which assumed a primordial body of the nature of a spiral nebula, we set about to study spectrographically these remarkable nebulae. While this work did not tell us what was the primary state of the solar system we did find it could not be such a nebula but that these nebulae were *very* distant, extremely large bodies and were flying through space with most enormous speeds. And thus was supplied the first observational basis of the present day theory of the expansion of the universe.

And once again, the search for Dr. Percival Lowell's predicted Planet X which led to its finding at Flagstaff in 1930, within a few degrees of his predicted place, encouraged further searching of a very large belt of the sky for still more distant members of our planetary system.

So we see how one undertaking has led us to a greatly expanded universe and the other to a much enlarged solar system, both inviting much subsequent investigation. Yet these are only a few outstanding examples of progress in astronomy. Still others might be given, but these may suffice to make it evident that there is real need for new and well equipped observatories, that there is ever so much more to learn, and that there are many more fields to explore.

In conclusion I bring to the David Dunlap Observatory, to Mrs. Dunlap, its donor, to its director, Dr. Chant and his colleagues, the cordial greetings

and good wishes of the Lowell Observatory. May your labours meet with results more fruitful of knowledge than your fondest hopes.

The last of the recipients of degrees to address the audience was Dr. W. E. Harper, who said:

I am deeply conscious of and grateful for the high honour just conferred upon me. I feel that any little thing I may have accomplished in the past does not merit such recognition; nevertheless, the honour will stimulate me to greater endeavours in the future.

I have often been asked, "How on earth did you come to take up the study of astronomy?" The answer can be given very definitely. I entered the University intending to qualify as a teacher of mathematics in High Schools and Collegiate Institutes. Early in my second year, though, I attended lectures on astronomy given on certain nights each month in the lecture room of the Chemical Building. I was attracted to the subject by reason of these interesting addresses given by Professors Chant, DeLury and other members of the local Astronomical Society. On entering my third year to continue my Mathematics and Physics course it seemed the logical thing to select the option which led to specialization in astronomy.

At that time I was not aware of a new observatory being under construction at Ottawa, so my choice was not in any way influenced by considerations of a "bread and butter" job. However, about the time I was ready to graduate they needed some one at Ottawa and, being recommended from here, I had the somewhat unique experience of being informed a few minutes after the graduation ceremony that I had been appointed to the Ottawa Observatory. That was how I entered astronomy.

The every day uses of astronomy do not obtrude themselves upon our notice, yet they are none the less important. The determination of accurate time, so necessary in our modern age, the application of our science to precise surveying and the delimitation of national boundaries, the calculation of the tides, the determination of the position of a ship at sea, or the aeroplane on a long flight, are all illustrations of where a knowledge of astronomy is essential.

But there are other uses, not necessarily of practical value, but worthy of consideration, nevertheless. In our quest for the beautiful in life we miss one of the richest sources of all if we have not an acquaintance with the stars. Emerson expresses the idea in this way: "If the stars were all to be blotted out and were to make their appearance only at long intervals, say once in a hundred years, how, as the critical time approached, the whole world would await with expectant awe, the oncoming of the gorgeous spectacle and how they would treasure for generations to come the glimpse they had been given of the City of God." Yes, the stars are a source of wonder and beauty.

Astronomy is a subject also that we should have some little acquaintance

with if only to appreciate the many allusions to it in literature. Poetry of past ages has been rich in references to what was known as "the music of the spheres." The planets and other celestial bodies were each supposed to be affixed in a sort of crystalline shell or sphere and as these spheres rotated about their common centre, the earth, the soft gliding of one over the other produced a harmonious strain always referred to as the music of the spheres. Numerous such allusions abound in literature and can be appreciated only by those having some knowledge of the subject.

A knowledge of astronomy, moreover, prevents one being a prey to fear when catastrophies are predicted for the earth. In earlier days, before comets were known to be regular members of our system, one can understand the alarm the unexpected appearance of a comet would produce. They were supposed to be harbingers of some dire catastrophe to come upon the earth. Pestilence and death followed in their train, so it was thought. Such concern and anxiety should not exist in our day, and yet it does.

Again, if we knew even the rudiments of astronomy we would realize the hoax that is perpetuated in the casting of horoscopes which even in our enlightened 20th century still clutter up the pages of the daily newspapers. Many people are still living in the superstition of the middle ages when it was believed that the stars and planetary configurations affected one's destiny. How worthy is a knowledge of the subject if only to rid us of this all-too-prevalent gullibility.

We need not enlarge further upon these more or less practical claims for consideration, for they are unimportant in comparison with the contributions which the pure knowledge side of astronomy has made. Professor Shapley has just referred to the difficulties the astronomer finds himself in by reason of the thin atmospheric covering that surrounds us. That is bad enough but can we picture our present state of civilization if the earth were externally shrouded in clouds, thick enough to obscure the heavenly bodies from view, though not sufficient to cut off the sun's energy. We would, of course, know something of the earth's surface and a mile or so of the atmosphere but we would be creatures of restricted outlook, nevertheless. We would go on with our work of raising potatoes and wheat for food, always looking down, never up, knowing nothing of the great universe, save this thin stratum of earth and air—such would be our condition to-day. Indeed, with the heavens in open view such might even be given as a picture of life 400 years ago before the days of the telescope, the spectroscope and the photographic plate.

The main purpose of astronomy, then, is to understand the universe. It is not that such knowledge will yield any financial returns, although there is rarely ever a discovery in pure science but contributes directly or indirectly to others which have practical applications. However the astronomer works with no such aim in view, but simply for the sake of finding things out.

I have thought that to illustrate something of the advances made in solving

the riddle of the universe during the 29 year interval since I last stood upon this platform on a similar occasion, I might refer to the item of radial velocities mentioned in the all-too-generous citation just read. In 1906 the number of stars whose radial velocities were known was about 400, chiefly determined at the Lick and Yerkes Observatories. The work taken up at Ottawa and for the past seventeen years at Victoria has resulted in Canada having a very creditable share in this phase of astronomical work. Of the 7000 stellar velocities now known, approximately 2000 have been determined at Victoria, although not all have as yet been published. In this work I have had some small share.

Much as has been learned from such researches we can nevertheless say with a great scientist of a former age that what we have explored is but the smallest portion of the great ocean of truth.

President Cody then spoke of the various distinguished guests on the platform and welcomed them individually. He asked Mr. Mackenzie King to address convocation.

Mr. King stated that it was his purpose to attend the opening ceremonies at the observatory without being seen in Toronto or missed in Ottawa. He had been seen in Toronto; how well he had avoided being missed in Ottawa he could learn when he returned. He wished to pay tribute to all those who had contributed to the realization of the construction and completion of the observatory. It was a great day for the University and a great day for the country, but also a day of remembrance for the whole scientific world.

He most warmly thanked Mrs. Dunlap and praised her selection of such a memorial to her husband. The David Dunlap Observatory was a combined monument, resembling a double star, of which the components are so close as to seem to be one, to the generosity of the donor, and to the memory of her husband. He spoke kindly of the long-enduring and unflagging enthusiasm and determination of Dr. Chant, and rejoiced in this happy culmination of his plans.

From his own personal point of view, he spoke of his happiness at being able frequently to return to his Alma Mater. He did not come for relaxation, nor recreation, but because, in the University, he found real inspiration for his own life. And in the realization of such a magnificent, unselfish, and noble project he found an especial inspiration.

Convocation was then dismissed.

SOME ADDITIONAL GREETINGS

From the Dominion Astrophysical Observatory, Victoria, B.C.
(Telegram to C. A. Chant)

Birthday greetings and hearty congratulations to all your staff.

(*Signed*) STAFF, *Dom. Astro. Obsy.*

From the Victoria Centre, Royal Astronomical Society of Canada—to Professor Chant

The Victoria Centre of the Royal Astronomical Society of Canada has learned with much pleasure of the completion of the David Dunlap Observatory with its reflecting mirror of 74 inches diameter.

The Executive desires to extend, on behalf of the Centre, its heartiest congratulations to you upon the fulfilment of your cherished ambition to secure such an observatory for Canada and in particular for the University of Toronto. Through your association with the *Journal* as Editor the members have come to feel that they know you personally and wish to send you this message of congratulation and best wishes for the success of the observatory.

We should like to place on record also our appreciation of the great contribution Mrs. Dunlap has made to the higher life of the country in the gift of such a splendid observatory. The aid she has thus rendered the cause of pure science will, we trust, be an example to other Canadians to do likewise.

To the University which receives this splendid gift to administer, we would offer our congratulations also, realizing that through the use of this new equipment researches will be possible which will add additional lustre to the University.

Signed on behalf of the Victoria Centre, R.A.S.C.

H. BOYD BRYDON, *President.* GORDON SHAW, *Secretary.*

From the Vancouver Centre, R.A.S.C.—To Mr. Harper

I wish to thank you for your kind letter, and request that while in the east you convey from the Royal Astronomical Society, Vancouver Centre, hearty greetings and congratulations to Prof. C. A. Chant, to whom we have for many years been deeply indebteded for his valuable services to Astronomy and particularly for his being instrumental in securing the new David Dunlap Observatory for our country.

(*Signed*) C. A. MCDONALD, *Secretary.*

From the Edmonton Centre, R.A.S.C.—To Mr. Harper

I have been instructed by Dr. Gowan, president, to say that we would be glad to have you convey to Dr. Chant greetings and congratulations from the Edmonton Centre of the R.A.S.C.

(*Signed*) G. A. CLARKE, (*Secretary*)

From Prof. J. W. Campbell, University of Alberta, formerly President of the Edmonton Centre.—To C. A. Chant

Our Centre has been glad to join with other Centres of the Royal Astronomical Society in extending to you our best wishes and congratulations on the opening of the new observatory, but I should like to add a personal word of greeting. I want to express my appreciation of your cordial and kindly interest in all the matters that I have had to bring to your attention, and for the generous assistance you have always given when called upon;—and not only for the academic interest and assistance you have given, but also for the cordial hospitality of your own home which it has been my privilege to enjoy.

I regret that Mrs. Campbell and I are not in the east this week to partcipate in felicitations to you and Mrs. Chant on the occasion of this very fitting recognition and reward for your achievements in the interest of astronomy, but please accept this intimation of our very best wishes to you both.

(*Signed*) J. W. CAMPBELL

From the Winnipeg Centre, R.A.S.C.—To C. A. Chant

It is with great pleasure that we ask Mr. W. E. Harper, who is attending the 1935 meeting of the Royal Society of Canada, to convey to you the greetings of the Winnipeg branch of the R.A.S.C.

We have followed the planning, building, and equipping of the new Observatory at Toronto with great interest and pride, and, realizing how much of this fulfilment is due to the untiring efforts of you and your associates we, on the occasion of the official opening of the David Dunlap Observatory, send you our felicitations, greetings, and hopes that you may be spared long to direct the Observatory, and that, notwithstanding the noteworthy contributions made by Victoria and Ottawa to the science of astronomy, Toronto may outshine them both.

Good luck and good seeing, always!

(*Signed*) WINNIPEG CENTRE,
per L. T. S. NORRIS ELYE (*President*)

From Prof. A. Vibert Douglas, McGill University, Secretary of the Montreal Centre, R.A.S.C.—To C. A. Chant

It is a matter of great regret to me that I cannot be present on the momentous occasion of the official opening of your observatory. I would have liked to add my humble congratulations to those of the many distinguished well-wishers who will be with you on that occasion.

May health and strength be granted you to enjoy the fruit of your labours and to see the David Dunlap Observatory achieve a reputation for valuable

research. May great happiness be yours on your birthday and through the succeeding years.

(*Signed*) A. Vibert Douglas.

Mr. George R. Lighthall, president of the Montreal Centre, was present at the opening of the Observatory.

Dr. Ralph E. DeLury and Mr. Clarence B. Hutchings of the Ottawa Centre were also present.

Professor H. R. Kingston, former president of the London Centre, with Mrs. Kingston, attended the opening.

Of the Toronto Centre a large number of members were present, including Professor L. Gilchrist, president of the R.A.S.C. and Mr. A. R. Hassard, K.C., chairman of the Centre.

THE DAVID DUNLAP OBSERVATORY*

By R. K. YOUNG

With Plates X-XVII

THE David Dunlap Observatory, the gift of Mrs. Jessie Donalda Dunlap to the University of Toronto as a memorial to her husband, will be formally opened on May 31, 1935. It is very fitting that the Observatory should be opened on this date, which is the seventieth birthday of the Director, for Dr. Chant has spent the greater part of his life in fostering astronomy within the University and in encouraging its study throughout Canada. The purpose of this article is to tell briefly the story of this magnificent gift and to say something of the research which will be carried on by the new observatory.

ASTRONOMY IN THE UNIVERSITY

The progress of astronomy as a department of the University is due to the continued efforts of Dr. C. A. Chant to emphasize its importance as a cultural subject in education and as a training for the advanced student. It was a part of his plan, even from a very early date, that the University should have an observatory and contribute to the knowledge of the subject, but it was hardly expected that the money for its erection would be obtained from the provincial grant to the University. In an institution striving to meet the needs of the province and expanding rapidly, chief emphasis in the field of science was likely to be placed on subjects more immediately utilitarian. Not until these had been taken care of would the claims of a pure science like astronomy be considered. The interest in the subject in recent years has been much increased by the spectacular discoveries which have greatly extended our knowledge of the universe and which have appealed to the imagination.

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*Reprinted with slight revision from the *University of Toronto Quarterly*, Vol. IV, No. 3, April, 1935.

Astronomy owes much also to the great body of amateurs whose interest in the subject has strengthened the desire that an efficient telescope might be situated within the province. The late David Alexander Dunlap was one of these. He was a member of the Royal Astronomical Society of Canada and attended the meetings of the Toronto centre. Dr. Chant in all his lectures before the society and throughout the country has emphasized the observational side of astronomy and the need of an observatory. If those who give instruction in astronomy are to possess that inspirational touch which comes only from an intimate knowledge of the subject, they must either be actively engaged in astronomical research, and thus be extending the frontiers of the science, or must be thoroughly informed regarding the work carried on in the observatories of the world. Lacking the equipment for the former, Dr. Chant followed the latter course; but he constantly emphasized the need of a first-class observatory. It was his hope that aid in this project would be received from Mr. Dunlap, but the latter's death in 1924 prevented this. When, some time later, Professor Chant suggested to Mrs. Dunlap that she should provide the observatory as a memorial to her husband, the suggestion met with a sympathetic response. Indeed, Mrs. Dunlap shared her husband's interest in astronomy.

General Plans and Location

In 1927 Mrs. Dunlap expressed her willingness to provide the observatory, but it was not until June of 1928 that we were in a position to call for the construction of the various instruments which would be installed. The original plan, which has been closely adhered to, contemplated two buildings: one, a steel structure to house a large telescope; the other, an administration building for office work and the reduction of the observations. There was no haste about the construction of the latter building since it offered no particular difficulties, but the main telescope was ordered as soon as possible because the time required for its construction was somewhat uncertain, this being especially true of the large mirror which forms the essential optical part of the telescope.

The location of the observatory was an important point to decide. Dr. Chant and the writer spent many afternoons inspecting

the maps of the neighbourhood of Toronto and visiting the possible sites. It was not thought advisable to go more than twenty or twenty-five miles away from the city, and locations north or north-west were much preferable to those east of the city. Most of our clear weather comes with west or north-west winds, and at these times the smoke from the city is blown south-east or east. A considerable amount of experimenting was carried on to determine the transparency of the air thirty, fifteen, and four miles from the city, as well as the amount of sky-illumination. In this regard the stations thirty and fifteen miles away proved far superior to that near the city, especially in the matter of the sky-illumination. The gain between thirty and fifteen miles did not seem to warrant placing the observatory at the more distant station. The site finally chosen is about twelve miles north of the city limits and about five-eighths of a mile to the east of Yonge Street on the highest land in that immediate locality, the summit being eight hundred feet above sea-level. The land falls away in all directions, giving a remarkable view of the surrounding country. At present the land around the observatory is quite open, with a few trees and shrubs scattered here and there. From an astronomical point of view it would be better if the land were more heavily wooded. On an open plain the ground becomes hot during the day; and when, after sunset, the heat is given off again, the warm air flowing upwards creates an unsteady atmosphere which interferes with the use of the telescope. Trees and vegetation absorb a great deal of the sun's heat so that a steady state of the air is reached much more quickly. Accordingly, it is intended to make the land into an arboretum, to be known as the David Dunlap Park.

Awarding the Contracts

Comparatively few firms possess machinery large enough to handle the massive castings of a great telescope, and there are still fewer with experience in telescope-building. The tentative specifications were sent to four firms: Carl Zeiss in Germany; Sir Howard Grubb, Parsons and Company in England; Warner and Swasey Company of Cleveland; and J. W. Fecker of Pittsburgh. The Warner and Swasey Company did not submit a tender, and the

design of the Carl Zeiss firm was considered less satisfactory than the one selected. There was not much difference either in the designs or prices of the other two firms, but after due consideration it was decided to accept the tender of the English company. This was a very fortunate choice because the decrease of the pound sterling made the cost very much less than it would have been if the contract had been let in the United States. It was very satisfactory, also, that the complete contract for the mounting, for the steel building to house the telescope, and also for the optical parts, could be let to one firm. This made it much easier to ensure that the finished equipment would assemble without difficulty when it arrived. Each of these three items merits some description.

The Circular Steel Building

The building to house the large telescope was ordered in November, 1931, and it was received in Toronto on July 31, 1933, (in pieces.) As has been already stated, the entire building is of steel construction. The circular drum and the hemispherical dome resting on it have double walls, and an open space at the base of the building admits air, which circulates to the top and goes out through openings with baffle plates at the upper part of the dome. The inside and outside of the dome are covered with "agasote," a hard paper product, and the outside is further protected by a sheeting of copper. By this means the interior of the building is kept cool during the day, and in the evening when thrown open for observations the whole building soon assumes the temperature of the outside air. Thus the "definition" of the telescope is not interfered with by heated air-currents, as would undoubtedly be the case if any quantity of heat were stored in the walls. The dome, which weighs about eighty tons, rests on twenty-four rollers, twenty-seven inches in diameter, running on a circular track. The entire dome may be rotated so that the opening, which is fifteen feet wide and extends from the bottom to seven feet beyond the zenith, may be made to face any part of the sky. Two parallel shutters run on rails at the top and bottom of the dome and cover or uncover this opening. The building cannot be heated because of the air-

currents which would be set up. In the cold weather the observer must dress for the occasion.

The Mounting of the Telescope

The telescope which the building houses is comprised essentially of the big mirror and a suitable means to hold it and direct it toward any part of the sky. The mirror, which consists of a block of glass seventy-six inches in diameter and about twelve inches thick, weighs about five thousand pounds, and consequently the mounting must be correspondingly heavy. This mounting is so constructed that the telescope can be pointed to any desired part of the sky and be continuously moved by clockwork in order to follow any object from the east to the west as it passes across the sky owing to the rotation of the earth. Although the moving parts of the mounting weigh upwards of thirty tons, this motion must be perfectly steady. It demands great perfection in the construction. The completed mounting, with the exception of the mirror, was received in Toronto on October 15, 1933.

The Great Mirror

When the telescope was ordered, in 1930, we knew that the portion which would probably take the longest to complete was the big mirror. At that time the Grubb-Parsons Company controlled the Parsons Optical Glass Works at Derby; and Sir Charles Parsons, the head of the C. A. Parsons and Company, of which these other companies were subsidiaries, was confident that they could manufacture a suitable disk of glass for the telescope mirror. (Incidentally, Sir Charles Parsons was the youngest son of the Earl of Rosse, who completed a six-foot reflector in 1845.) But Sir Charles was in his seventy-sixth year when the order for our telescope was placed, and unfortunately he did not live to see the disk made. Had he lived I have no doubt that his active interest and ingenuity would have solved the difficulties and pushed the task to completion. But in 1932, after his death, the disk had not yet been cast, and it

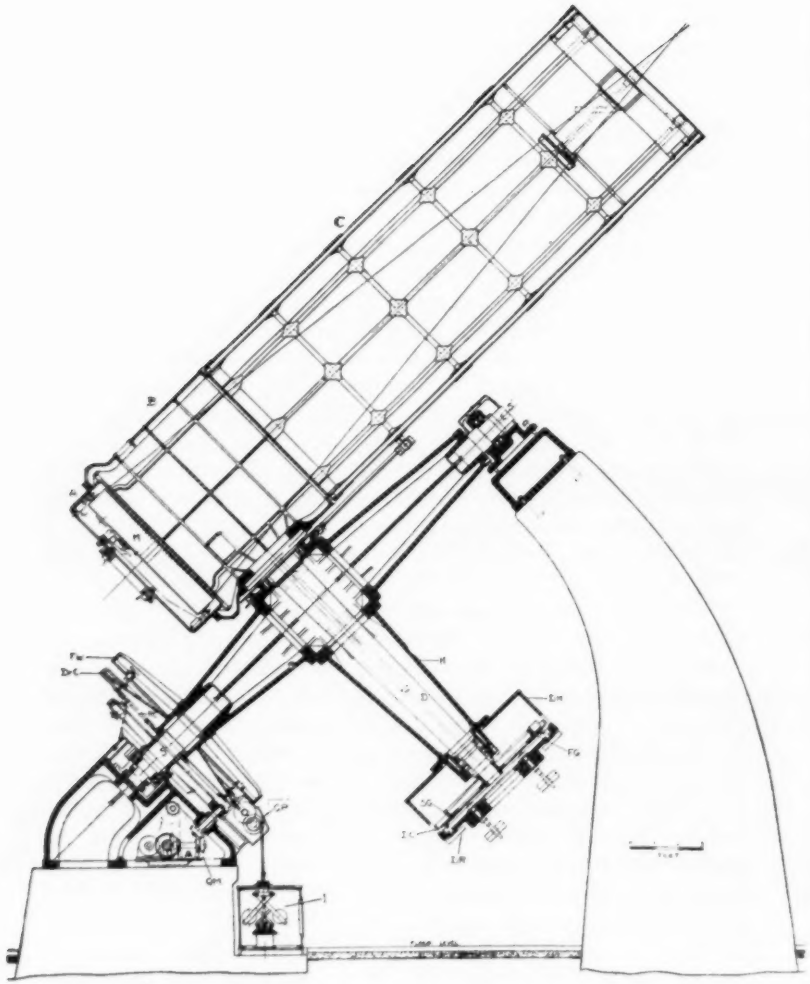
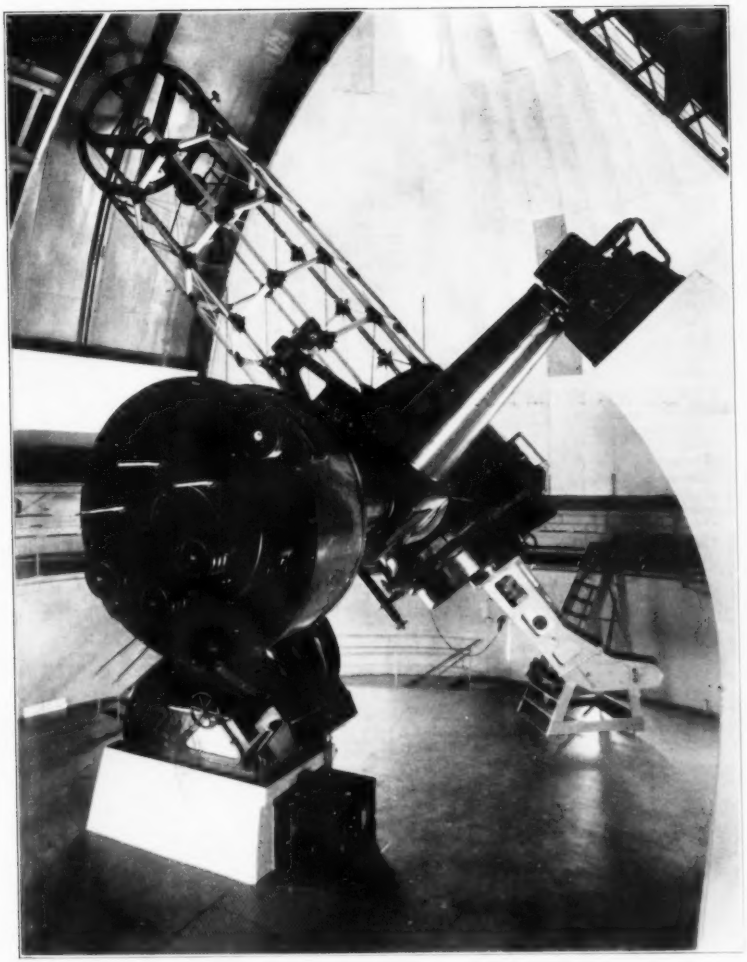


FIG. 1.—Vertical north-south section of the 74-inch telescope

PLATE X.



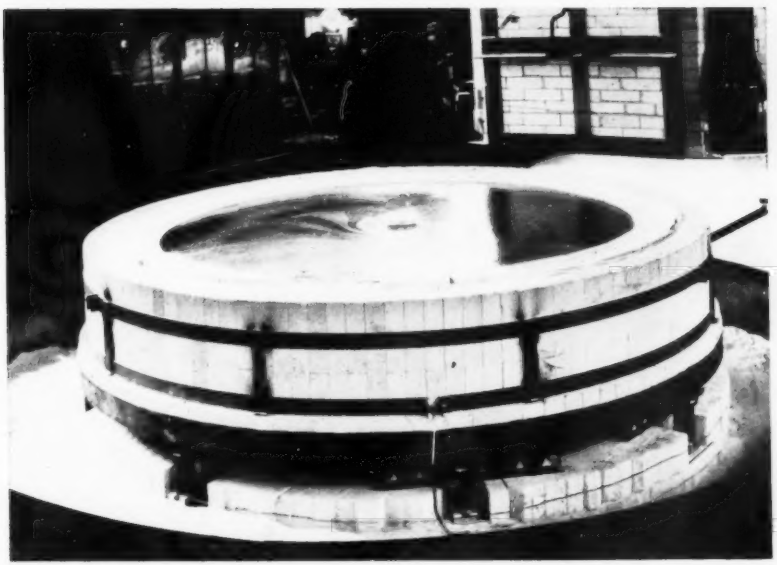
THE 74-INCH REFLECTING TELESCOPE.

PLATE XI.

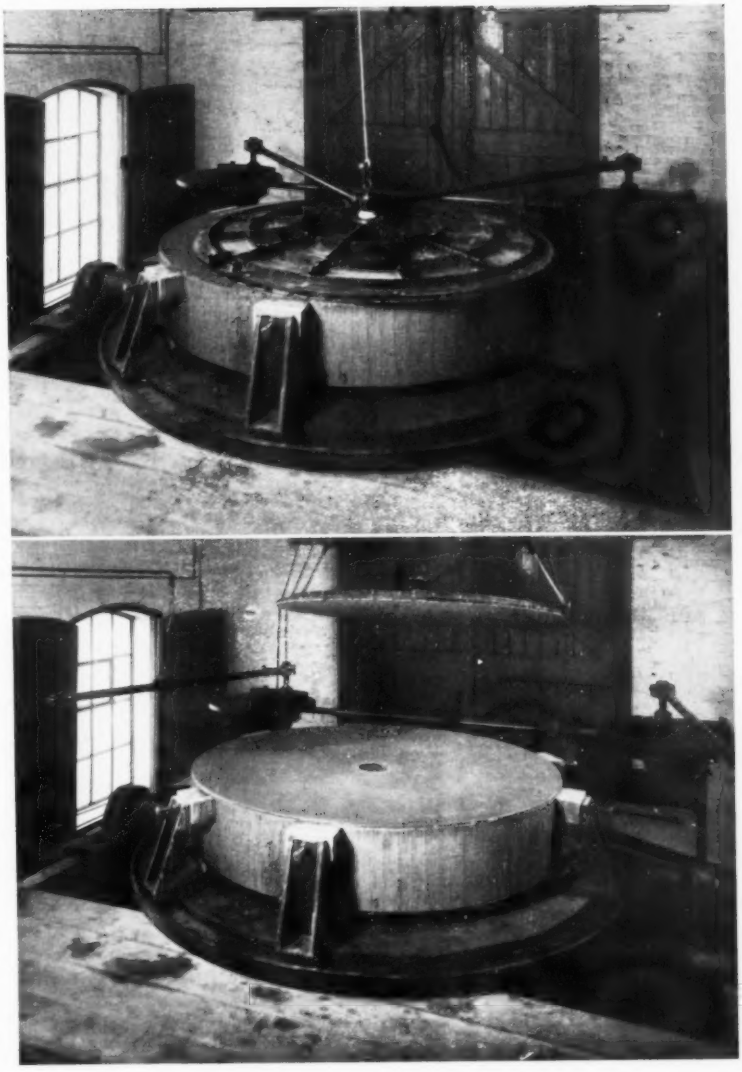
ENTRANCE HALL, ADMINISTRATION BUILDING.

THE LIBRARY OF THE DAVID DUNLAP OBSERVATORY.
The portrait over the mantel is of David A. Dunlap.

PLATE XIII.



THE DISK OF GLASS FOR THE 74-INCH MIRROR IN ITS MOULD AT CORNING, N.Y., JUNE 21, 1933.



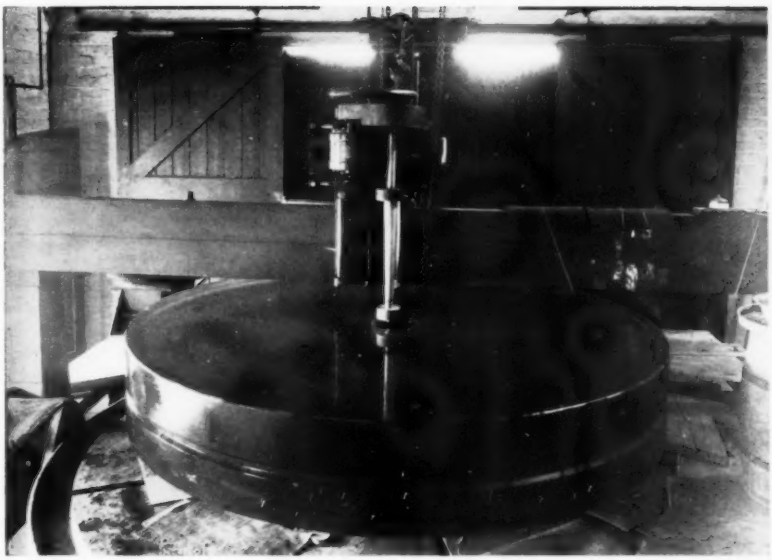
THE DISC FOR THE 74-INCH MIRROR.

ABOVE—The grinding tool on the concave surface.

BELOW—The tool raised, the rough grinding completed. When cast the disc was 76¾ inches in diameter and almost 14 inches thick. (Photograph at Newcastle in December, 1933.)

Journal of the Royal Astronomical Society of Canada, 1935.

PLATE XV.



THE DISC IN THE SHOPS AT NEWCASTLE-ON-TYNE, MAY, 1934.
The disc has been ground approximately to shape; the hole in the centre is being bored out.

PLATE XVI.

THE GREAT MIRROR.

The mirror has just been lifted from its case and a belt is about to be placed around it.
May 7, 1935.

In front—J. F. Heard (left), F. S. Hogg.

At rear—A. Young (left), E. O. Stockman.

Journal of the Royal Astronomical Society of Canada, 1935.

PLATE XVII.

THE GREAT MIRROR.

The mirror is being lowered into its steel cell, May 7, 1935.
In front—C. A. Chant, (left) R. K. Young. *In rear*—F. S. Hogg.

seemed that the project for our observatory might be unduly dealyed.

However, in 1932 unexpected help arrived in connection with the manufacture of telescope mirrors, which was not available in 1930. In the latter year the only firms which would undertake the manufacture of large disks were Carl Zeiss in Germany and the Glass Works at Derby in England. On the American continent the Corning Glass Works, of Corning, N.Y., had made some small "pyrex" disks of glass which were superior in every way to any that had been previously made, but this firm was extensively engaged in the commercial manufacture of pyrex articles and was not prepared to undertake the expensive experimenting necessary to manufacture so large a disk as we required. But between 1930 and 1932 conditions changed. Plans had been put forward for the manufacture of a disk for a two-hundred-inch telescope and time and money spent in finding out the most suitable material. In the end it was decided that "pyrex" glass offered the best hope of success for this disk. The Corning Glass Works was prevailed upon to install the necessary furnaces and annealing ovens for the task. We were informed late in 1932 that they were prepared within six months to cast our disk. From the first we should have chosen this material for the large mirror had it been available at the time. The Grubb-Parsons Company gave the contract for the manufacture of the raw disk of glass, which was to be shipped to England to be ground and polished into the final mirror. It was with great hope and satisfaction that our party from Toronto, including Mrs. Dunlap, Dr. Chant, and others, was present in Corning on June 21, 1933, and saw the disk poured from a special type of "pyrex" developed for telescope mirrors. Possibly with still greater satisfaction Dr. Chant and the writer inspected it on September 29 of the same year after it had come from the annealing oven, and saw a disk whose appearance met all our hopes.

No time was lost in shipping it to England. It was still to be ground and polished, and Mr. C. Young, the manager of the Grubb-Parsons Company, estimated that this would take eighteen months. Only those who have attempted to make a telescope mirror can really appreciate the difficulties that are encountered in such a task. The material is fragile and the disk heavy, and the surface has to be

FIG. 2.—Unloading the Great Mirror from truck into Dome, May 2, 1935

shaped true to an extraordinary degree of accuracy. The figure of the mirror, we are informed, now warrants the makers in ceasing work on it. Measures and photographs which have been received lead us to believe that the surface is in no place at fault more than one millionth of an inch.

The Administration Building

The large telescope will be an effective instrument of research. In addition to the building containing it, it is necessary to have a suitable place where the plates taken with the telescope may be studied, where the staff can have office space, and the activities of the observatory be directed. The construction of the Administration Building was conducted by the University's Superintendent of Buildings and Grounds, who also had charge of the erection of the steel building, of securing the water supply, of the electric installations, and of other essential details. Great credit is due to his management and to the architects, Mathers and Haldenby, for the fine appearance of the building, both within and without. It is a stone structure, built on classical lines, and is situated about two hundred and fifty feet from the great dome.

On the roof of the building three domes were erected for the accommodation of smaller instruments. The central and north domes are at present vacant. In the south dome is a nineteen-inch telescope which was built at the University. This telescope, we hope, will prove a valuable accessory to the larger instrument and may be used on many programmes of research when the large telescope is not available.

In the Administration Building is also the library of the Observatory. Original plans for a special endowment for the library could not be carried out and this essential adjunct to research is not yet satisfactorily provided for. The Observatory and the University of Toronto are indebted to the Royal Astronomical Society of Canada for the loan of the more technical part of its library to the Observatory for a term of three years. The library is not nearly as complete as it should be and will have to be supplemented either by generous grants from the University or from funds obtained from other sources.

The Work of the Observatory

Almost the entire research programme of the Observatory will be carried on photographically. It is estimated that during a year we shall have about one hundred and twenty-five clear nights with twelve hundred observing hours. The large telescope will be in use from sunset to sunrise, either in directly photographing regions of the sky or in the employment of auxiliary instruments such as the spectroscope with which the spectra of the stars are secured. Considerable time will have to be utilized at first in testing the accuracy of the instrument and in determining methods of work in order to make the labour of the limited staff as efficient as possible. Only after operating for a number of years can an observatory have accumulated that wealth of astronomical photographs which forms the basis of research on many astronomical problems. After this is secured there is forthcoming a steady stream of valuable work. It will probably take a number of years for us to reach this goal, and the first duty of the staff will be to accumulate the observational material. While a new observatory is thus handicapped for a time, it has compensating advantages: it can utilize all previous experience in order to obtain the material in a superior form, so that it can be used for more lines of investigation.

On account of the large size of the new telescope, the second largest in the world at the present time, we shall be able to secure much material which has never before been obtained. Astronomers throughout the world, through their organizations and publications, are well informed regarding the work which is being carried on, and the various observatories co-operate in the prosecution of researches for which their equipment is best suited. The David Dunlap Observatory will participate in the field of stellar velocities, spectral photometry, and in other co-operative labours. The major part of the observational programme will be devoted to such researches, and by contributing to the advances in astronomy it is hoped to justify the generosity of the donor in presenting the University of Toronto with this magnificent instrument.

ON RETIRING

During the last twenty years the nature of "time" has been a subject of much lively debate. The publication of Einstein's General Theory of Relativity caused great intellectual quickening, not only in academic circles but among factory workers, in mining camps and in outposts of empire. Is time absolute? Has it a separate independent existence or does it depend on something else?

For two centuries Newton's definition was universally accepted —at least by students of physical science:

> Absolute, true, and mathematical time, of itself, and from its own nature, flows equably without relation to anything external, and by another name is called duration.

Space also is treated by him in similar simple terms which seem clear to all! And yet Einstein and his supporters, who sprang up everywhere, boldly stated that time and space were simply relative notions. According to Minkowski,

> From henceforth space in itself and time in itself sink to mere shadows, and only a kind of union of the two preserves an independent existence.

However when a person is told that he has reached the age of three-score-and-ten and that he must therefore retire, whether he likes it or not, he feels that time is pretty absolute after all.

About two decades ago I had the opportunity of examining the records made at the Meteorological Office at Toronto for many years past. For Wednesday, May 31, 1865, the day of my birth, the following entry was found:

> Temperature at 2 p.m., 76°; mean for the day, 68°.4. Fair day. Hazy round the horizon. Frogs noisy at night.

The site at which these observations were taken is now on the grounds of the University of Toronto. For May 31, 1935, seventy years later, at a station half a mile farther north, the atmospheric conditions are embodied in the following summary which is ab-

stracted from the elaborate record as now taken:

> Temperature at 2 p.m., 69°.9; mean for the day, 64°.01. At 2 p.m. the barometer read 29.759 in. which, reduced to freezing point and sea level, was 30.062 in.; relative humidity, 41; visibility, 8. From 7.45 a.m. to 12 noon, partly cloudy. Light rain from 7.35 a.m. to 9.30 a.m. At 2 p.m., partly cloudy; at 4 p.m. generally clear and sunny.

It need hardly be remarked that to hear the frogs now one would have to travel several miles from this station.

There is another semi-meteorological or semi-astronomical matter which might be referred to. We speak of a blooming maiden of sixteen summers or a hoary veteran of eighty winters, meaning that these individuals are sixteen or eighty years old, respectively; but I have seen only sixty-nine summers although I can claim seventy-one winters. The anomaly is to be credited to the eclipse of 1922, of relativity fame. Leaving our country in June of that year, a summer in Canada was exchanged for a charming winter in Australia, with the numerical result indicated.

It is in no spirit of protest that I withdraw from active service on the staff of the University of Toronto and put on the quiet gown of the emeritus professor. The regulation requiring retirement at a definite age is a good one. There are younger men, keen of mind and vigorous of body, who will carry forward the work. I shall miss the peculiar pleasure experienced by the instructor in his contact with his students, especially when they are growing into manhood and womanhood. But such will not be entirely absent. Life for me began many years ago, assuredly before forty, and it will continue after seventy. In my pleasant quarters at the Observatory I shall have more leisure to pursue investigations in which I am interested.

Further, the projects in the University and the Royal Astronomical Society of Canada, to which I have given special thought and effort, are, I think, now firmly established. They will assist in the moulding of human thought in the future just as astronomical discovery and research have in the past centuries.

During the many years in which I have conducted this JOURNAL I have not printed any verses of which I could claim authorship. Indeed many moons have displayed their phases since I ventured

upon the sea of poetry. I hope I may be pardoned if I now introduce some stanzas which were written over forty years ago; and although they do not require any elucidation they may carry a little greater interest if I explain how they came to be produced.

In 1887 after completing my first year examination at the University I went with a class-mate—long since passed away—on my first camping trip. We launched our canoe in the Stony Lake region where there were then very few summer cottages. I find the following brief record:

> On Wednesday, July 13, a very hot day, we went to Jack's River with the intention of climbing the (so-called) Blue Mountain. After walking several hours and losing our way we at last reached the summit. From it was a glorious view. Over a dozen small blue lakes could be seen.

In the autumn of 1891, I was asked to send a contribution to *What-Not*, a magazine published by the Literary Society of the St. Catharines Collegiate Institute. It appeared in the Christmas number. Perhaps it is more appropriate now.

"OLIM MEMINISSE JUVABIT"

I

We camped upon the lakelet's shore,
  And paddled on the river's breast;
We slept upon the grassy floor
  When earth was in her sable dressed.

We climbed the mountain's rocky side
  Beneath a scorching August sun,
And many times our strength was tried
  Before the lofty crest was won.

And though at night, so sore of foot,
  With toil and heat quite overworn,
Refreshed with sleep, we urged our route
  When Phœbus rose the morrow morn.

But now a kindly memory knows
  No thought of pain or blistering ray:—
The thorns of pleasure's fragrant rose
  All vanish in the after-day.

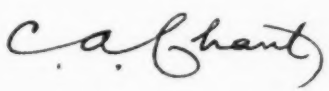
II

For years, upon the broadening stream
  Of learning has our little bark
Been moving on,—too slow, we deem,
  But ever on towards the mark.

We search the much-indented shore
  And chart the reefs and shoals we see,
Though oft, beneath the heavy oar,
  The body sinks in agony.

Upon the bank, with nightly toil,
  We seek to climb the rugged steep,
But ere we trudge a single mile
  We fain would lie to rest in sleep.

Yet time a rosy glamour throws
  O'er all the hardships by the way:—
The thorns of learning's fragrant rose
  All vanish in the after-day.



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